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ABSTRACT

A study was conducted to determine whether programmed instruction or traditional instruction in chemistry was more effective in terms of student preference, student achievement, achievement of students with low reading levels, and achievement of students with high reading levels. Two non-random groups of students with equivalent learning ability in chemistry were established. The total group was also divided according to reading level. Groups alternatively received traditional instruction and programmed instruction for each of five learning modules. Each group was pre-tested at the outset of each instructional module. Post-tests were administered at the conclusion of the modules and average gain scores were tabulated. Scores were also tabulated for the high and low reading groups. Findings of the study included: (1) no significant differences were found in achievement between the two methods of instruction; (2) approximately 60% of the subjects preferred programmed instruction while the remainder preferred traditional instruction; (3) there were no significant differences in achievement, according to teaching method, of high or low reading level students. It was recommended that students be given the option, when feasible, to choose either type of instruction. An extensive bibliography is appended. (JDS)

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Comparison of Traditional Instruction and Programmed Instruction in Chemistry

WILLIAM E. CHEEK

A MAJOR APPLIED RESEARCH PROJECT
PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF EDUCATION

NOVA UNIVERSITY

1976

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Abstract of a Major Applied Research Project Presented to
Nova University in Partial Fulfillment of the Requirements
for the Degree of Doctor of Education

COMPARISON OF TRADITIONAL INSTRUCTION AND PROGRAMMED INSTRUCTION IN CHEMISTRY

By
William E. Cheek

May 1976

Programmed instruction was developed in chemistry at Central Piedmont Community College (CPCC) as a part of a school-wide instructional revolution beginning about 1971. This development took place with little objective evaluation either in the area of chemistry or on a school-wide basis. Some of the professional staff at CPCC felt that student achievement was less when programmed instruction was used and that students preferred the traditional methods of instruction if given a choice. Others on the staff felt that programmed instruction (PI) was superior to traditional instruction (TI) and that students much preferred the newer method.

This study was conducted to determine which of the two methods was the most effective in terms of the following: (1) By which method will the chemistry student prefer to be taught, (2) By which method will chemistry students achieve the most, (3) By which method will a high reading level chemistry student achieve the most, and (4) By which method will a low reading level chemistry student achieve the most.

The t-test was used to determine if the difference in the mean gain scores for the two methods was significant. It was found that there was no significant difference in achievement in the two methods at the 0.01 level. However, at the 0.10 level, PI achievement was significantly greater on two of the eight units. Achievement by TI was not significantly greater than PI on any of the units at the 0.10 level.

When students were asked directly the method by which they preferred to be taught, PI was highly preferred to TI on four of the five modules covered in the study. Chi-square analysis of rating scales indicates a slight preference for PI. A most significant finding in the study was that students preferred TI on the one module involving a closed lab situation under supervision of the classroom teacher.

The t-test was run on the overall gain scores for the high reading group both for PI and TI. The results indicated there was no significant difference in achievement. The t-test was run on the overall gain scores for the low reading group on PI and TI. The results indicated no significant difference in achievement.

Recommendations were made to continue further development of PI for both classroom and lab but to convert the open chemistry lab to a semiclosed lab, taught and supervised by the classroom teacher.

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Chapter I

BACKGROUND AND STATEMENT OF THE PROBLEM

INTRODUCTION

Many changes have occurred in the field of education in the last decade. Two of these have had a pronounced effect on the community college and, especially, the educational approach at Central Piedmont Community College (CPCC). Firstly, there has been an increase in the variety and depth of learning due to the "knowledge explosion". Secondly, there is a greater acceptance of learning as a lifelong process rather than a terminal one. Thirdly, educators understand better and are more aware of individual differences among learners and recognize the need for diverse methods of instruction.

CPCC has been keenly aware of these changing needs and, by the summer of 1971, a tremendous movement was underway at the college to develop programmed instructional materials or techniques in all areas of instruction. To promote this, the instructional staff was granted leave time to attend workshops and conferences and to participate in extensive training in the art of developing programmed instruction. This movement was further supported by on-campus workshops, concerned with the writing of specific behavioral objectives and the other aspects of developing programmed instruction. During the initial stages of the development of programmed instruction, much instructor release time was available but the amount of time was decreased substantially following the initial work with the new methods of instruction. To support and to maintain the development of programmed instruction, professionally trained personnel were hired to aid the individual instructional staff members in their efforts. Again, this was a school-wide movement in which a welding instructor was just as likely to be writing learning objectives as the college transfer instructor. An indication of the basic school philosophy underlying this innovative instructional movement is well illustrated in the stated school philosophy as adopted by the Board of Trustees and expressed in the college catalog (CPCC General Catalog, pp. 6-7).

> The College is aware that the implementation of these objectives in an open door admission environment will bring to its campus students who differ greatly in age, motivation, and purpose as well as educational and personal background. The challenge of educating these students cannot be met with traditional methods of instruction alone. In recognition of this face the following policy statement has been adopted by the Trustees of the College:
>
> "Central Piedmont Community College is committed to the concept that, given enough time, most students can accomplish any learning task. This is based on the concept that students basically differ in their rates of learning rather than their ability to learn.
>
> This commitment carries with it a resolve that the College must have as a major objective the provision of ample opportunities for students to learn at varying rates. It also implies a belief in the concept of individualized control of the rate of learning."

The Trustees and staff of the College are dedicated to the task of creating the environment for learning which is defined in the above statements of philosophy, objectives and policy.

Further insight into the philosophy of the school is revealed in the "Items of Special Emphasis for Personnel" stated on the CPCC Application for Employment form....

> CPCC is dedicated to good teaching as a primary goal. All members of the faculty and staff contribute to this goal. Each faculty member, as an integral part of the team, is expected to feel an interest in and demonstrate enthusiasm for all aspects of the college program--not merely that of his/her own department or discipline. CPCC stresses a results-oriented approach based upon specific behavioral objectives for each staff position. This is at the heart of the College's emphasis upon accountability and cost effectiveness.
>
> CPCC is committed to providing alternative ways by which students can learn. It places heavy emphasis on the availability of individualized instruction and multimedia approaches to learning.
>
> CPCC believes that learning is more than accumulation of facts. Opportunities for a student to meet with teachers on a one-to-one or small group basis are important in the learning process. To make these opportunities possible, CPCC expects its faculty members to be on campus and available to students throughout the daily work period as agreed upon with the appropriate department head.
>
> CPCC is a "people-centered" institution dedicated to serving its constituency, to fairness in inter-personal relations and to nondiscrimination on matters of race, age, religion, national origin, color, sex and other factors unrelated to helping students achieve objectives.
>
> Organizationally, the College delegates the authority and responsibility for decision-making and policy-implementation to those persons closest to the problem. The department head, consequently, is an administrator not a faculty member who presides at departmental meetings. The outcomes of the teaching-learning process as defined by the department within the objectives and the philosophical framework of Central Piedmont Community College are the responsibility of the members of the department and the department head.

> CPCC efforts to achieve its objectives require dedication on the part of all--everyone on the team. If these expressions of philosophy and beliefs do not agree with those you hold, it would be in your best interest, as well as that of CPCC, to seek employment in an institution that has a philosophy and beliefs atuned to those you hold. (CPCC Application for Employment, pp. 1-2)

Obviously, the administrative staff that was responsible for policy setting at CPCC, in consideration of the properties of the learner and the potential learner, felt that new methods of instruction were needed for the "new kinds" of students entering the open doors of the college. The conviction that new methods were needed led ultimately to the innovative instructional movement. Upon examination of the properties of the typical CPCC student and comparison with a typical non-community college student, it will be found that a very striking contrast exists between the two. This observation lends support to the decision that a need exists for the reevaluation of the traditional modes of teaching in this community college.

A local study completed by Kirby (1974) on the "Learning interest of the Adult in Mecklenburg County" provides some insight into the type of adult student and potential adult student at CPCC. A concise summary of some of the most significant findings of the survey are included.

1. Over seventy percent (168,000 persons) of the adult population of Mecklenburg County would like to learn more about some subject or skill.
2. Adults in Mecklenburg County are interested in a very wide range of subjects and skills.
3. Interest in learning is present in all social and economic strata of the county population and focuses more strongly on vocational subjects.

4. Adults are most interested in learning simply for the sake of knowledge--secondarily, they are interested in learning as a means for achieving personal, principally vocational, goals.

5. Most adults still prefer the familiar lecture and classroom modes of instruction and see the community college or technical institute as the preferred location for learning.

6. Most adults would like to receive some form of formal recognition for learning achievement and would most prefer that such recognition be communicated to themselves, their family or friends.

7. Time, cost, and the pressure of home and job responsibilities are the greatest obstacles to continued learning for adults.

8. The average adult learner spent about four hours per week in learning activity for a period of five months, probably did or will complete the course and financed the instruction from his own or family funds (Kirby, 1974, pp. 13-14).

CONTEXT OF THE PROBLEM

For the past five years, the writer has been involved extensively in developing programmed instruction (PI) in chemistry at CPCC. Due to a constraint of time and various other problems, this development was carried out with little objective comparative evaluation with traditional instruction (TI)--the method it has partially replaced. The need for a comparative study of traditional instruction (TI) with the new instructional approach (PI) used in general chemistry at Central Piedmont Community College was obvious.

Numerous studies have been made comparing traditional instruction (TI) and programmed instruction (PI) but few have been conducted in the field of chemistry in the community college. Each institution, and more particularly, each community college has its own unique educational environment, and a need exists for evaluation of instruction in each institution. This need is paramount if the institution is to choose the most effective instructional methods to serve its students.

The overall need for improved instruction in the field of chemistry is shown by the low percentage of student success in practically all levels of education in chemistry from high school through four years of college. For example, Berchin (1972) found that only forty-five percent of the students successfully completed the general chemistry preparatory course (Chemistry 51) at Sacramento City College, while a respectable seventy-two percent of the students enrolled in the conventional general college chemistry class (Chemistry 101) for science and engineering students completed the course successfully at Meramec Community College in St. Louis. The success rate in the first quarter of General Chemistry 1504 at Central Piedmont Community College is about sixty percent - sixty percent of those who start do obtain credit by the end of the quarter. Some of those who do not complete the course do so the following quarter. This percentage is a little higher than the corresponding math course (Math 1504) and less than the percentages in other areas, such as the social sciences.

Chemistry has long been a basic subject needed for many professions and technologies, and chemistry courses have been used to "weed out" the apparently weaker student in such fields as medicine, pharmacology, etc. Many courses have been used for this purpose but it appears that the difficulty encountered in the learning of chemistry make it one of the most desirable.

Haight (1976) strongly implies that a need exists for the overall evaluation of educational methods of teaching chemistry in light of the (1) increased volume and sophistication of knowledge in the field, (2) the expansion of the student population, including the less well-prepared chemistry student, (3) the development of technical aids to teaching and learning, and (4) the attempt to define student goals and limited objectives (pp. 5-6).

One of the major problems in chemistry education appears to lie at the introductory level and not with more advanced courses. A recent study at the University of Illinois found no junior level chemistry majors who ranked below the ninety-fifth percentile in his/her high school class (Haight, 1976). Students with this kind of ability appear to do well on any level of chemistry and, most likely, in any subject area.

George Hammond, recipient of the 1976 American Chemical Society's Priestly Medal (the highest honor in American Chemistry) criticized the field of chemistry as being "highly conservative", and chemical research as being "frequently repetitive and stylized game playing, with elegance evaluated more highly than innovation." He projected that chemistry might disappear as a separate discipline. Hammond describes chemistry education as too inflexible, conservative and having too little variety (Seltzer, 1975, p. 28).

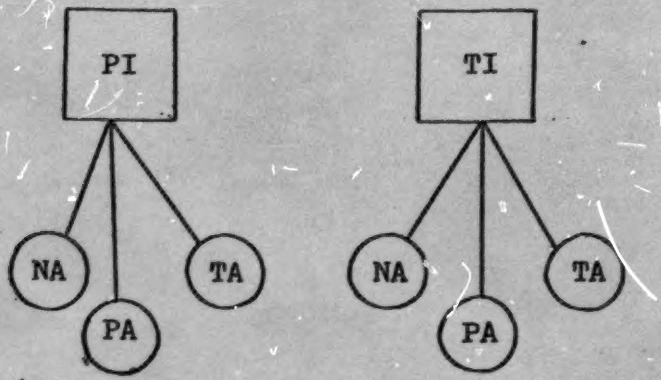
Based upon considerable teaching experience in math and science (general science, biology, physics and chemistry) at various levels of education--junior high, senior high, four-year college and U. S. Army Signal Corp--the author can state without reservation that chemistry is one of the most difficult of these sciences for the student to learn and the teacher to teach. It appears that improved instruction is needed as much or more in chemistry than any other field of science. Constant instructional evaluation is needed in teaching to recognize, identify, and solve teaching and learning problems. This is especially true for new instructional approaches.

CLASSIFICATION OF TRADITIONAL INSTRUCTION (TI) AND PROGRAMMED INSTRUCTION (PI)

Studies of this type would best begin with a recognition and definition of three types of programmed material and three types of lecture classes. They are classified as (1) non-adaptive (NA) material, (2) partially adaptive (PA) material, and (3) totally adaptive (TA) material. An illustration of these types of categories is shown in the following diagram:

Diagram 1

CATEGORIES OF PI AND TI



(1) Non-Adaptive programmed material and lecture material does not permit the deviation of presentation based on individual learning characteristics. Each student is presented identical materials, steps, frames, etc., in dependent and sequential order. There is no program or learning material adjustment made for individual differences in learning characteristics at levels a student will need. The non-adaptive lecturer teaches subject matter, not students, discourages questions, is overly concerned with covering specified material in a limited time, is orderly to a fault, arrives and leaves punctually, has little or no out-of-class time for student conferences, and is subject oriented. Typical common remarks from students exposed to this type of instruction includes: a) goes too fast, b) expects all of us to be as interested in the subject as he is, c) has no time for the student, d) dry,

e) uninteresting, f) boring, and g) "he knows the subject but can't teach it".

(2) Partially Adaptive programmed material permits the presentation of selected material based on student's questions and/or responses to previously presented information. The quality range of these types of materials varies widely and is dependent upon the knowledge and skill of the author and of his awareness of the characteristics of the target group. Considerable success has been obtained at Central Piedmont Community College (in the area of chemistry) by the utilization of partially adaptive material. The ingredients for success appear to be a specific definition of the learning task, awareness of areas or concepts which offer difficulty for the learner, and knowledge of the learning characteristics of the student body. Typical comments from students exposed to this type of instruction include: a) good, b) I like it, c) I can proceed at my own rate, d) review is easy, e) no difficulty in determining what is important, and f) no one knows how well I am doing, except me.

Partially adaptive lectures are sensitive to individual differences but operate within a time frame which inhibits total individualized attention. As a result, many questions go unanswered. Individual conferences are encouraged but, with large classes, are limited to short question and answer periods in most cases. Student comments most often related to this type of instruction include: (a) good instructor, (b) goes too fast for me, because I learn slower than others, (c) I should have taken a more elementary course, (d) I am spending an awful lot of time on homework, (e) I seem always to be ten days behind, (f) the exam grade does not reflect what I know, and (g) I could have done better if I'd had more time.

(3) Totally Adaptive programmed material adapts completely to the individual learning characteristics in terms of method of presentation, time of presentation, and the details of explanation. The ideal totally adaptive system has not yet been designed and/or put into practice. CAI, interactive television coupled with a dial-access and computer are systems that offer much more promise in this area.
A totally adaptive lecture exists primarily in a tutor system involving instructor and one student (McIntosh, 1971).

Both the PI and TI used in this study fall into the class of partially adaptive material, and this should be understood in any future reference to PI and TI in this study.

It is believed that many of the contradictions which arise from various comparative studies of TI and PI are a result of the failure to recognize the necessity for like comparisons within the categories of classification. It is possible to compare one section of a course taught by the so-called lecture-traditional method with another, programmed, section of the same course and find that the traditional section was taught in a highly adaptive fashion, even including partially programmed instruction. In other words, a traditional class can include highly adaptive programmed instruction in the lecture. The highly adaptive lecture is the exception rather than the rule, however. On the other hand, it is possible to have the other extreme, whereby the traditional instruction is totally non-adaptive with the programmed sections being highly adaptive to the learner's needs. These types of studies demand that the methods of instruction be well defined if the results are to be valid. An examination of the programmed instruction included reveals the adaptive nature of the material to be used in this study. For example, the "what you should know now" section and the pretest illustrate a consideration for individual differences of the learners.

STATEMENT OF THE PROBLEM

The Major Applied Research Project (MARP) study attempted to determine:

1. Which of the two methods of instruction (PI or TI) will result in greater achievement by general college chemistry students at Central Piedmont Community College.
2. By which of the two methods of instruction will the Central Piedmont Community College chemistry student prefer to be taught.
3. Which of the two methods of instruction will result in greater achievement by Central Piedmont Community chemistry students of high reading ability.
4. Which of the two methods of instruction will result in greater achievement by Central Piedmont Community College students of low reading ability.

PURPOSE OF THE STUDY

The purpose of this study was to determine the effectiveness of programmed instruction in chemistry at CPCC as compared to the conventional methods. As previously stated, CPCC had committed itself to the concept that most students can learn and that faculty members should investigate alternative methods of instruction in search of improved teaching and learning techniques to meet the changing needs of the complex student body of the college.

One of the earliest programs to be initiated on campus was the Audio-tutorial (A.T.) individualized lab program in biology written by Postlewait at Purdue University. The program met with much student-instructor enthusiasm.

The A-T program in biology was followed by the on-campus development of individualized programmed instruction in biology, business, auto-mechanics, chemistry, etc. Much of the early developmental work in chemistry was carried out in a "highly rushed fashion" with the typical neophyte mistakes being made. Due to the lack of classroom and lab space, once a commitment was made to produce programmed instruction for one class, it was difficult not to involve the other classes within the same classroom and labs. It was found that once programmed instruction was developed for a portion of the course, many students demanded and expected programmed instruction for the entire course. Most of the instructional development was completed without release time from normal teaching duties, requiring the sacrifice of much of the instructor's free time at home as well as at school. Thus, the situation as described left no time for objective comparative evaluation. It was believed by many of the faculty members and students that programmed instruction was somewhat superior to traditional instruction but little objective evidence was gathered to support this belief. An improved grade point average for students using programmed instruction, in addition to favorable student evaluation in most cases, indicated that programmed instruction was, apparently, at least equal to conventional instruction in student achievement and student response. As a result, the professional staff of CPCC was spending a tremendous amount of energy in the development of new methods of instruction in several areas of the institution with little scientific evaluation of the methods. The faculty members were encouraged to develop and implement new methods of instruction but little effort was made to encourage evaluation of adopted methods. In consideration of this, it was felt that a "real need" existed for this comparative study in chemistry.

Chapter 2

REVIEW OF RELATED LITERATURE

For organizational purposes this review of related literature is divided into three parts, each dealing primarily with comparative studies of TI and PI in various areas of education. The first part deals with studies of TI and PI in the area of general education, the second, with studies in all fields of science except chemistry, and the third part, with studies of PI and TI in the area of chemistry. Various aspects of PI and TI will be considered such as cost, adaptability to different areas of education, student and teacher preference and effectiveness as determined by comparisons of student achievement.

For the purpose of the review of literature, the following terms are defined: Traditional Instruction (TI) is teaching in the typical fashion with closed classroom, students and a teacher. This type may be referred to as classical or conventional instruction. In TI the class meets for a specified period of time and may involve lecture, discussion and/or question-answer techniques. Programmed Instruction (PI) is teaching and learning in which the instructor may or may not be present in person during the learning activity. PI may involve use of various delivery systems and will usually include learning objectives, detailed learning steps, frequent review and testing. PI is also defined as using all or part of Audio-Tutorial (AT), Computer Assisted Instruction (CAI), Computer Managed Instruction (CMI), the Keller Plan (PSI), the Systems Approach to the Instructional Process (SAIP), Coordinated Instructional Systems (CIS), Individually Prescribed Instruction (IPI) or Learning Systems Approach (LSA).

In some instances, in this review of literature, certain studies, considered to be typical of a particular methodology or containing valid data related to the proposed hypotheses, are described in detail. These examples were included intentionally to give the reader a more thorough insight into the general nature of the problem.

PI and TI in General Education

Sutherland (1975) completed an evaluation of individualized instruction for evening and part-time students in business administration. The study was part of a program initiated by the Business Department of El Paso Community College to improve the curriculum for the part-time students which were selected from a student body of about 70% Mexican-American. Most students in the group had learning handicaps due to poor secondary education. The study involved the use of individualized instructional packets for the "Introduction to Business" course.

Three (3) sections of evening students, having the same instructor and including identical learning objectives for all sections, were studied.

With one section (I), an individualized instructional unit was used; with another (II), the lecture method was employed and with the remaining section (III), the lecture method was used with students given optional use of the programmed unit as a classroom supplement. From results of the study, based upon achievement tests, it was found that the section given optional use of programmed material to supplement the lecture method scored significantly higher than the other two sections. No significant difference was found between the other two sections. The small number of students (20) that utilized the optional material in the third section made the results of that part of the study questionable.

Conroy (1971) completed a study of the effects of age and sex upon achievement in PI and CI in remedial Algebra I at a Northern Virginia Community College. An analysis of the equality of means of paired samples using the t-test showed student age to be significant. The study showed that other students achieved more, that sex was not found to be significant in achievement and, when sex and age were held constant, no significant difference resulted from the use of programmed instruction versus conventional instruction. The researcher suggested that further studies of the relationship of age and sex to achievement be made and that PI and CI be utilized to maximize student achievement.

Giese and Stockdale (1966) compared the effectiveness of programmed and conventional workbook methods of teaching grammar, sentence structure, punctuation, and capitalization in a Junior College. Two teachers participated in the experiment with each teaching the PI and workbook sections. The researcher found no significant differences among the treatment groups and concluded that remedial English courses could be taught as effectively by PI as by the conventional method.

White (1970) completed a study in which the effectiveness of an individual study approach to Associate Degree Nursing at El Centro Community College in Dallas, Texas was evaluated. The purpose of this study was to determine whether individualization of instruction would enhance learning and help solve problems of crowded student schedules, heterogenous ability of students and inexperienced instructors. One hundred and ten (110) freshman and sophomore students comprised two control groups which received TI and two experimental groups which received taped lectures and small group seminars. Achievement was measured and no significant difference was found to exist between the two groups. Recommendations were made that this individualized approach be expanded to include all nursing courses, and that a listening lab be constructed including carrels, tape players, and other A.V. equipment.

The question arising for possible consideration concerning this study is "Upon what basis does the researcher refer to this method of instruction as individualized instruction?" Actually, the lecture may have been more highly individualized than the taped material. This is an excellent example of the confusion concerning classification of instructional methods referred to in the introductory chapter.

The short and long-range learning that takes place in TI and PI is examined in a study by Packard (1967). In the fall of 1964, prospective students at the University of Minnesota were assigned to groups for a two-day orientation unit. The purpose of this orientation was to familiarize the student with general aspects of the University. The experimental group received the content from PI. The control group received the same information by TI. The PI group performed significantly higher on an immediate post-test. There was no significant difference between the two groups on their evaluation of the method of instruction used. One month following the session, a retest of student knowledge about the University showed that no significant difference existed between the two groups. The lecture group subjects were judged to be better prepared for registration since more members of this group completed the prescribed test as scheduled. The researcher recommended the use of both PI and TI in future orientation procedures.

An example of the apparent superiority of PI in teaching students how to use the dictionary is shown by Stockdale (1967). In one section of a reading and vocabulary development course in a Junior College, students were given PI while in another section, subjects were taught in the conventional way. In four of the eleven test scores of the experimental groups, PI exceeded the control group significantly.

The conventional group did better on only one of the tests. There was no significant difference between the two groups in six of the tests. As a result of this study, PI was accepted as the method of teaching use of the dictionary at this school.

Brinkman (1966) explained the possibility of using specially designed PI to teach the visualization of space relations. An approximately 500 item program was presented to twenty-seven eighth grade students and compared with a matched control group who received only the pre-test and post-test while being taught by TI in the math class. The results indicated that the subjects in PI scored significantly ($p < 0.001$) higher than the control group.

These results support the finding of Van Voornis (1941) who completed a similar study. His study indicated that the attitude of the learner may be an important factor in the effectiveness of PI. Analysis of the attitude survey indicated that those students who felt that teachers could teach better than a program scored consistently above the median on the post-test when taught by this method. Most subjects disagreed with the statement on the attitude questionnaire that "one does not have to think when learning by PI" (Brinkman, p. 183).

Brinkman's results are supported by Macomber and Siegel (1956) who found that students who initially held favorable attitudes toward a certain mode of instruction achieved more than those who did not have these attitudes.

The opinion of selected faculty at five community colleges in Florida concerning PI is probably typical of many instructors in the Community College today. Handleman (1975) surveyed seventy-four social science, English/Foreign Language teachers at five Florida Community Colleges. About 75% of the respondents indicated that they felt the rate of innovation in the community college system should be reduced, at least for the immediate future. Many of these instructors felt that innovations had resulted in academic grade inflation with a lowering of standards and de-emphasis on cognitive learning. The study indicated that the respondents were not opposed to innovative teaching techniques as such and would favor their use, if these methods were properly evaluated before wholesale adoption.

The use of the computer as an instructional medium has been proclaimed by some experts as having almost unlimited potential. Lawrence M. Stolurow, director of the CAI lab at Harvard, states that

> Computer-assisted instruction (CAI) is not the panacea for today's educational problems--there is no single solution to problems as complex as these.

However, Stolurow goes on to say:

> CAI is comparable to Gutenberg's invention of the printing press in terms of the potential effect it will have upon education (Silberman, 1970, p. 187).

Professor Suppes of Stanford, a noted CAI expert, says that:

> One can predict that in a few more years millions of school children will have access to what Philip of Macedonia's son, Alexander, enjoyed as a royal prerogative: the personal services of a tutor as well informed and responsive as Aristotle (Silberman, 1970, pp. 187-188).

It is interesting to note that Suppes, three and one-half years later, dismissed the above notion as hopelessly utopian

> If we could create the best of all possible worlds for the children in our society, we might wish that each of them would have a tutor of the quality of Socrates or Aristotle. As a general approach to mass education, however, this is clearly prohibitive economically (Silberman, 1970, p. 188).

According to Anastasio and Morgan (1972), the computer as an instructional medium has unique properties. The computer as an instructional medium is quite unlike traditional media and needs further study in some areas. Four differences between the computer and other instructional media were particularly underscored:

> 1. The procedures for the development and structuring of CAI materials vary from those traditionally employed in other instructional media.
> 2. The computer's versatility in assuming a variety of roles offers new possibilities for improving instruction; these roles range from passive informational resource to simulated instructor.
> 3. The responsiveness of the computer enables it to teach a process or dynamic system through interaction with a student.
> 4. The diagnostic capability of the computer enhances individualization of instruction; enormous quantities of information can be exploited about the past and present performance of a particular student. (Anastasio and Morgan, p. 32)

Much research has been done concerning the use of the computer in education. Some of these references are included in the area of general education.

Butler (1969) reports on the use of the CAI method in the lower grades in a study conducted in the New York City Schools.

> The only instances in which non-CAI students made larger gains than CAI students were at two grade levels in schools with predominantly Black or Puerto Rican population, and the differences were not significant. These results are generally in harmony with the numerous reports from teachers that CAI students seemed to be performing better than non-CAI students (Butler, p. 21).

Alpert and Bitzer (1970) emphasize that the usefulness of the computer in teaching should not be limited to rote learning and drill, as with arithmetic. They also believe that CAI should be extended far beyond an automated version of the Skinner teaching machine. They thought the computer should be of much value in the development of critical thinking, as well as the transfer of information.

The amount of instructional time required and the ability of students to retain learning by CAI is well demonstrated by Alpert and Bitzer (1970) in a description of the Plato system used at the University of Illinois:

> Initial experiments aimed at evaluating educational effectiveness have been made at the University of Illinois and elsewhere. The data sample is altogether too limited, but the results have been encouraging. For example, a class of 20 students in a medical science course was taught for a semester entirely with the Plato system. When compared with a control group in a nationally administered test, the students taught with the Plato system were found to have scored as well in grade performance even though they had required only one-third to one-half as many student-contact hours of instruction as those taught in the conventional classroom. Subsequent measurements extending over a 26-week period indicated that the Plato group showed greater retention over that interval (Alpert and Bitzer, 1970, pp. 14-15).

That CAI has been well received by some students and teachers is shown by a wide variety of experiments. Alpert and Bitzer (1970) list several key features of CAI that explain why computer-based education has aroused this enthusiasm.

1. The interactive nature of this instructional medium typically absorbs the attention and encourages the total involvement of students at all age and grade levels.

2. The student may proceed at his own pace and can exert considerable choice in the selection of alternative teaching strategies and methods of presentation.

3. The feedback of information is applied not only in the learning process but also in the teaching process; the system provides teacher or author with the means of assessing in detail the progress of the individual student, with a powerful tool for evaluation and modification of lessons, and with a mechanism for measuring overall educational effectiveness.

4. Lesson materials may be written or edited at a student console at any location while other consoles are being used by students. Thus, materials previously prepared elsewhere may be modified by a teacher in a participating institution (for example, a community college or a secondary or elementary school) in response to the particular needs of his own students (Alpert and Bitzer, 1970, p. 18).

Interviews with key computer personnel at CPCC reveal that the full range of the CAI technique has not nearly been reached (McIntosh and Kirby, 1975). They point out that it is qualitatively quite different from a film, programmed book or television presentation due to its flexibility and adaptability.

According to Anastasio and Morgan (1972), the computer is potentially the text, test, teacher, remedial specialist, A.V. specialist, guidance counselor and administrator all wrapped up in one coherent system (An example of CMI). If so, the full potential of the computer in education obviously has not been realized.

One of the main barriers to CAI acceptance and use has been that of economics. Many investigators feel that there are numerous, complex problems hindering the educational acceptance of CAI. Three of the more important ones are listed in order of most critical to least critical.

1. The lack of adequate software and CAI effectiveness.
2. Economics - the high cost of CAI.
3. Technical dimension difficulties concerned with creating adequate CAI delivery systems.

(Anastasio and Morgan, 1972, p. 11)

McIntosh and Kirby (1975) have indicated that in CAI trial programs at CPCC, they have found both the high cost and the shortage of good software to be the largest obstacles to CAI acceptance.

Anastasio and Morgan (1972) point out that one of the major impediments to CAI's acceptance in education was the lack of basic research in theories of learning, and that there exists a wide gap between the present theories of learning and their application. One application of the stimulus-response associationistic theory of learning is programmed learning, which has been the mainstay of teaching machines. Although B. F. Skinner was not the first to suggest this approach to teaching, he has popularized it the most. His idea was to treat classroom learning like any other situation in which certain behavior was to be shaped. He thought that the learner should progress gradually from the familiar to the unknown, and that learning should be often reinforced. The rate of learning will vary from person to person, and therefore a need for individualized instruction exists. Skinner's solution to this problem was his teaching machine utilizing programmed learning (Hill, 1963).

Programmed learning has been applied many ways, and it appears that the computer may hold the most complete mechanism for the implementation of this kind of learning.

PI and TI in Science Education

One of the earliest types of programmed instruction used at Central Piedmont was the Audio-Tutorial (AT) approach, similar to the type initiated at Purdue University in 1961. Since 1961, scores of AT programs have been developed and are being used in Community Colleges all over the United States. In most cases they are adaptations of the prototype used at Purdue. The evaluation of many of the AT programs have been somewhat subjective, according to Sparks and Unbehawn (1971). In a highly controlled and well designed experiment, these investigators compared the achievement of an AT section and a TI section of General Biology. The groups were formed after the students were administered the science portion of the American College Test (ACT). The design of the AT section of the course was nearly identical to the Postlethwait system. The AT group consisted of 190 students while the TI group included 180 students. The results indicated that:

1. The two groups selected for the study were equal in learning ability.
2. There was a significant difference in the achievement of students in the PI group in three of the units covered (Sparks and Unbehawn, 1971, p. 576).

Students in the TI section failed to excel significantly in any of the units. In addition to the achievement gain as measured by the Total Biology Test, student acceptance of the AT method was high. Ninety percent (90%) of those enrolled in the AT section indicated they would choose this type of instruction again.

Mintzes (1975) completed a survey of the AT approaches in which he summarized and evaluated the research on AT instruction. Table 1 shows a summary of the results of comparing TI and AT methods of instruction.

Table 1

COMPARATIVE METHODS STUDIES

Author	Type of Course	Analytic Procedure	Results
Russell (1968)	General Biology Junior College	Analysis of variance	Significant differences favoring conventional
Grobe (1970)	Biology for Nonmajors	Analysis of variance	No differences
Sparks and Unbehaun (1971)	General Biology		Significant differences favoring A-T
Rowsey (1973)	Animal Biology	Analysis of variance	Significant differences favoring A-T
Maccini (1969)	General Geology		"Significant gains" for A-T; no control
McClurg (1971)	General Geology	Analysis of variance	No differences
Hinds (1971)	Inservice Elementary Teacher Education		Significant differences favoring A-T

(Mintzes, p. 249)

In summarizing the results of the comparative studies, Mintzes states:

> The results of comparative studies appear to be inconclusive and even contradictory. Of the several studies reported here, three found the A-T approach to be significantly better, two found no differences, one found the conventional method better, and one failed to use a control group (Mintzes, 1975, p. 248).

A second type of study that has been made concerning AT is that which investigates the relationship between student characteristics and performance in AT courses. This type of study is labeled "Trait-Treatment Interaction" or "Aptitude Treatment Interaction. Mintzes (1975) indicates that results are somewhat contradictory at times, but a number of important conclusions appear to be revealed by current research:

> (1) strong backgrounds and/or aptitudes in science, and mathematics appear to contribute significantly to achievement in A-T biology; (2) personality measures such as the GZTS "restraint" and "ascendance" scales and the 16PF "intelligence" scale appear to be related to achievement; (3) biographical variables such as high school grades and class rank as well as college major and college grade-point average appear to be predictive of achievement. On the basis of these findings, it is apparent that a "general intelligence" factor is responsible in large part for the variance in achievement levels among students enrolled in AT courses, as in most other instructional situations (Mintzes, 1975, p. 249).

Table 2 summarizing this is included in the appendix.

Mintzes (1975), in a third general group of studies, surveyed unrelated instructional variables associated with the AT approach. The results of these are interesting and are summarized in Table 3.

Table 3

STUDIES OF INSTRUCTIONAL VARIABLES

Author	Type of Course	Major Question	Analytic Procedure	Results
Nord (1969)	General Biology	Achievement under varied attendance requirements	Analysis of covariance	No effect
Husband (1970)	General Biology	Effect of the "threat of a grade in the oral quiz section"	Analysis of variance	No effect
Hoffman and Druger (1971)	General Biology units on heredity	Comparison of "direct" and "indirect" A-T approaches	Analysis of variance on "loss scores"	Significant differences favoring "indirect"
Kelley (1972)	General Biology units on genetics	Effect of use of behavioral objectives in A-T lessons	Analysis of variance	Significant differences favoring objectives
Shields (1973)	General Biology	Effect of use of behavioral objectives in A-T lessons	Analysis of variance	No effect

(Mintzes, 1975, p. 251)

Berchin (1972) completed a study comparing the large group mode of instruction, individualized programmed instruction, and the AT mode of instruction in terms of learning outcomes and cost. This reference is deemed valuable because it deals with the Community Colleges that belong to the "League For Innovation" of which CPCC is a member. However, the study has some severe limitation, e.g. the limited time span, small number of courses involved and lack of randomly selected courses. Berchin concluded that:

> 1. Changing the pattern of classroom organization or the instructional mode can reduce per-pupil costs and increase learning effectiveness.
>
> 2. Courses organized under the large group mode of instruction generally are less costly on a per-pupil basis than conventionally organized courses.
>
> 3. Courses organized under the individualized programmed mode of instruction are generally less costly on a per-pupil basis than conventionally organized courses.
>
> 4. Courses under the audiotutorial mode of instruction are generally more costly on a per-pupil basis than conventionally organized courses.
>
> 5. Comparing the three nonconventional modes of instruction, courses under the large group approach are the least costly on a per-pupil basis, followed by those using the individualized programmed approach, and lastly, by courses under the audiotutorial mode.
>
> 6. Subjective data indicate that courses taught under one of the nonconventional modes of instruction generally produce more effective instruction than their matching conventionally organized courses. (Berchin, 1972, p. 4-5)

Table 4 relates the extent that AT is used in selected Community Colleges and an estimate of learning that is being realized with each method. The calculated average from the data in the table indicates little difference in the two methods with respect to percent completion and student grade indexes.

Table 4

A COMPARISON OF LEARNING OUTCOMES BETWEEN COURSES UNDER THE AUDIOTUTORIAL AND THE CONVENTIONAL MODES OF INSTRUCTION

Name of Course	District Where Course Is Given	Audiotutorial		Conventional	
		Percentage of Students Completing the Course	Student Grades (Weighted Index)	Percentage of Students Completing the Course	Student Grades (Weighted Index)
Algebra, Intermediate 013	Dallas County Community College District	19.23	.48	33.33	.79
Anatomy and Physiology	Central Piedmont Community College	93.55	2.75	96.63	2.90
Anthropology, Introduction	Santa Fe Junior College	83.33	2.65	66.87	1.96
Biological Concepts 110	Maricopa County Junior College District	55.36	1.71	80.34	2.73
Biology 1	Los Angeles Community College District	87.86	2.39	56.67	1.42
Biology 1A	Los Rios Community College District	80.19	2.35	85.45	2.45
Biology II	Coast Community College District	78.95	1.98	N.A.	N.A.
Biology 112	Brookdale Community College	48.89	1.07	N.A.	N.A.
Biology 115	Dallas County Community College District	62.38	1.47	60.31	1.27

Table 4

(Continued)

Name of Course	District Where Course Is Given	Audiotutorial		Conventional	
		Percentage of Students Completing the Course	Student Grades (Weighted Index)	Percentage of Students Completing the Course	Student Grades (Weighted Index)
Biology 115 and 101	Dallas County Community College District	73.51	1.85	85.61	1.70
Chemistry 51	Los Rios Community College District	42.11	1.00	45.16	1.06
Chemistry, General College	Junior College District of St. Louis	85.51	2.52	72.38	1.57
Economics 102	Brookdale Community College	47.06	1.32	N.A.	N.A.
Electronics 230	Brookdale Community College	77.78	2.56	N.A.	N.A.
English A-B	Coast Community College District	48.03	1.20	60.87	1.30
Humanities 1	Los Rios Community College District	86.26	2.29	95.53	2.87
Mathematics 115	Maricopa County Junior College District	N.A.	N.A.	N.A.	N.A.
Nursing 111	Delta College	69.31	1.89	90.32	2.06
Psychology 1A	Foothill Community College District	51.00	1.77	82.47	2.19
	Average	66.128	1.85	69.90	1.88

(Berchin, 1972, p. 31)

Table 5 concerns the comparison of learning outcomes between individualized programmed modes (excluding AT) and the conventional modes in the areas of science and math.

Table 5

A COMPARISON OF LEARNING OUTCOMES BETWEEN COURSES UNDER THE AUDIOTUTORIAL AND THE CONVENTIONAL MODES OF INSTRUCTION

Name of Course	District Where Course Is Given	Audiotutorial		Conventional	
		Percentage of Students Completing the Course	Student Grades (Weighted Index)	Percentage of Students Completing the Course	Student Grades (Weighted Index)
Data Processing I	Foothill Community College District	62.50	2.12	86.67	2.40
Developmental Math. and Elem.	Junior College District of St. Louis	64.70	2.46	80.00	1.90
Electronic Repair 50	Los Rios Community College District	95.00	N.C.	56.67	1.37
General Physics	Santa Fe Junior College District	N.A.	N.A.	37.93	1.21
Mathematics 117	Moraine Valley Community College	59.04	2.22	81.82	2.18
Physical Science I	Junior College District of St. Louis	71.43	1.86	86.67	2.47
Physical Science 121	Santa Fe Junior College District	87.50	2.79	100.00	2.90
	Average	73.35	2.29	75.69	2.06

(Berchin, 1972, p. 31)

Tables comparing the learning outcomes of the large group mode and the conventional mode of instruction and a comparison of instructional cost are included in the appendix as related information.

The decrease in North Carolina State revenue available for education in 1976 has resulted in an increased emphasis on educational cost accountability at CPCC with respect to methodology. Berchin (1972) compares the cost of AT and TI in Table 6.

Apparently the cost of AT Instruction is significantly higher than conventional instruction based on the averages calculated from this table.

Table 6

A COMPARISON OF DIRECT INSTRUCTIONAL COSTS BETWEEN COURSES UNDER THE AUDIOTUTORIAL AND THE CONVENTIONAL MODES OF INSTRUCTION

Name of Course	District Where Course Is Given	Audiotutorial Cost per Pupil	Conventional Cost per Pupil
Algebra, Intermediate 013	Dallas County Community College District	$ 21.60	$ 42.96
Anotomy and Physiology	Central Piedmont Community College	49.93	29.33
Anthropology, Introduction	Santa Fe Junior College	15.65	20.04
Biological Concepts 110	Maricopa County Communitty College District	104.50	54.64
Biology 1	Los Angeles Community College District	76.78	49.93
Biology 1A	Los Rios Community College District	194.48	159.13
Biology II	Coast Community College District	56.35	N. A.
Biology 112	Brookdale Community College	81.73	N. A.
Biology 115	Dallas County Community College District	41.29	46.20
Biology 115 and 101	Dallas County Community College District	41.31	102.48
Chemistry 51	Los Rios Community College District	113.58	127.35

Table 6

(Continued)

Name of Course	District Where Course Is Given	Audiotutorial Cost per Pupil	Conventional Cost per Pupil
Chemistry, General College	Junior College District of St. Louis	$ 76.28	$ 76.78
Economics 102	Brookdale Community College	46.32	N.A.
Electronics 230	Brookdale Community College	100.11	N.A.
English A-B	Coast Community College District	16.58	29.83
Humanities 1	Los Rios Community College District	41.43	30.57
Mathematics 115	Maricopa County Community College District	70.81	54.12
Nursing 111	Delta College	303.96	339.77
Psychology 1A	Foothill Community College District	16.57	18.17
	Average Cost	96.81	78.75

(Berchin, 1972, p. 81)

Taber (1974) compared the results of conventional instruction and PI in a course, "Electrical Circuits", offered in the Mechanical Engineering Technology program at Cuyahoga Community College. PI was based on the PSI approach as used in the Keller Plan. The most important results were:

1. The percentage of students that completed the course as taught by PI was significantly higher than those finishing in the TI sections. These results are comparable with those in most studies involving AT courses.
2. The grade received by each student was independent of the method of instruction used (Taber, 1974, p. 37).

McAlexander (1975) compared the achievement of students enrolled in Physics I who were taught by TI or PI. He found that a significantly higher number of students successfully completed this course in PI sections (PSI, Keller Plan) than those in TI sections ($p>.05$). The study also indicated that a significantly higher percentage of the student receiving PI achieved A or B than those receiving TI ($p>0.05$).

Another comparative study by McAlexander (1975) at CPCC in the area of Shop Science revealed greater achievement using PI than TI. The study involved two different instructors both of whom taught a PI and a TI section. In each instance, the PI section achieved significantly more than the TI section.

Brantley (1974) completed a comparative study of AT and TI in a physical science class at Pensacola Junior College in Florida. The results of the study revealed that:

1. TI taught students achieved significantly more than AT taught students.
2. There was no difference in achievement with respect to age and sex among students taught by either method.
3. Students whose ages were 21 years or older scored significantly higher in both AT and TI groups.
4. The final grade in the course taught by AT was directly proportional to the amount of time spent in lab.
5. The attrition rate was higher in the TI section.

PI and TI in Chemistry

One of the few comparative studies of PI and TI in high school was made by Summerlin (1971) funded by a NEW grant. The purpose of the study was to determine the effectiveness of short-term tutorial-type CAI in selected topics in high school chemistry. The TI group was taught using an informal lecture-discussion style typical of high school teaching. No films or other AV equipment were used in the TI section. The CAI units were designed to allow the students to progress at their own rate. The computer program was able to make the decision as to whether a student needed review at any given point in the unit, based upon the number of incorrect responses given. After each incorrect response, the computer gave the student supplementary information and indicated whether the student should try again or return to a previous section of the program. If the student continued to enter incorrect responses to the same questions, he was directed to a reading assignment or given the correct answer and a solution scheme for the problem. Students could review after each series of presentations by the computer. If students elected to review, they were given supplementary information explaining each problem, using a different approach than was used in the first exposure. Students also had an opportunity to be directed to an advanced tract if their responses were consistently accurate. A description of the computer program used in this study reveals it to be a well-planned and well thought-out program. The results of this study showed that students in the CAI group appeared to learn twice as fast as those in the TI group because they completed the program in about 40% of the time required for the TI group. While the TI group scored significantly higher on the post-test than the PI group (20% higher), the CAI program was rated high by most students in the study. They were satisfied with their learning using CAI, and many felt that CAI was superior to TI. Yet, when they were asked by which method of instruction they preferred to be taught, they selected TI because "the teacher has a personality and the computer doesn't" (Summerlin, 1971, p. 26).

CAI has been used in some lab experiments with some success. Suppes (1973) reports that a portion of the freshman chemistry lab work at the University of Texas has been computerized. This was done partly because of the very large number of students (over 3,000) taking general chemistry.

Some way had to be found to replace a portion of the laboratory activity with simulation.

An example of one experiment being used with success is described:

The time required to complete a typical "titration curve" experiment in general college chemistry (or QUANTITATIVE ANALYSIS) using a PH meter, stirrer, burette, etc., will range from two to three hours depending upon the operator. This titration would include only one acid, using no more than two dissociation constants. This same experiment may be completed in much more detail using the computer as described by Breneman (1974)....on a UNIVAC series 70/46 computer, only five and one-half minutes of computer time is required to titrate a total of fifty acids with one to four dissociation constants each. In addition, the titration curves are plotted for each of the acids and each of the constants. Thus, a student could obtain much more data in much less time with the computerized lab than the traditional lab. In the typical titration experiment, the student does little more than add small increments of reagent and record the pH meter readings. In the opinion of the author, if this particular experiment were computerized, the student would miss very little lab experience.

Wilson and Atkenir (1968) report that computerized lab programs in advanced chemistry involving complex and/or dangerous experiments have been considered successful from an educational, economical and safety standpoint at the University of Texas.

Cheek (1975) completed a brief study, with a quasi-experimental design, in which CAI was compared with TI to determine by which method the student preferred to be taught and by which method the student achieved more in a unit in general chemistry. The study was limited to a small group of students because of class size and the availability of only one computer terminal for student use. A detailed description of this study is included in the appendix because of its similarity to the Major Applied Research Project.

O'Connor (1974) has come up with yet another new program called the "Learning Systems Approach". This method is very similar to many of the other individualized, programmed designs. The new program, in use at Texas A & M University, apparently increases the amount of achievement while decreasing the learning time for the student in freshman chemistry. Student evaluations were favorable and both learning and student self-satisfaction were dramatically improved, although no statistical date was presented in the article to validate the reported success.

It appears that four-year college chemistry faculty attitude toward new methods of learning is becoming more like the attitude of faculty in the typical community college. This is well illustrated in a quote from O'Connor (1974, pp. 18-19).

> What this system means to the student is that the faculty cares about him and will do everything possible to provide a variety of ways to help him learn the subject. It also means that the student must care enough to assume the responsibility of using whatever means necessary to learn the material. The system will work if the student works.

Vandenbroucke (1975), in search of alternatives to the standard lecture approach in chemistry, has experimented with the use of both the programmed text by Runquist (used at CPCC as a supplement) and with the Personalized System of Instruction (PSI) in freshman chemistry at Wartburg College, Waverly, Iowa. This study dealt primarily with a comparison of PSI and TI. Student response to the PSI method was somewhat favorable with the number of students transferring in and out of the PSI section about equal. The results of a student evaluation questionnaire indicated that sixty-seven percent felt that they would prefer the PSI approach in future chemistry courses. Seventy-six percent rated the course above or well above average, while only 3% rated it below average. Test results showed that there was no significant difference, in general chemistry, between the levels of achievement when students were taught by PSI or TI. In his conclusion, Vandenbroucke points out that:

> Students tell you that they feel they learned more in PSI. While the test results in this study seem to contradict this, possibly we are not testing for the kinds of things the students are learning! They leave the course with a better feeling about chemistry than do students in lecture sections. More important, the students have a better attitude about learning, and learning is the goal of teaching (Vanderbrouke, 1975, p. 516).

Hedrick (1975) used a modified form of the Keller Plan (PSI) at Elizabethtown College, Pennsylvania in an introductory chemistry course. The Keller Plan was used from 1970-1973 and the results compared with achievement prior to 1970. Hedrick (1975) found that the modified Keller plan did not yield results on the A.C.S. Standardized Examination (Form 1967) that were significantly different from TI. This study indicated related that response to PSI was positive and students seemed to like the self-pacing aspect of the method. Especially, they liked the option of exam retakes. The investigator felt that, in consideration of the amount of student and faculty time spent on the three-year project, results were discouraging because, although grades were higher under PSI, student scores on the A.C.S. Exam remained about the same. For the academic year 1973-74, the discussion group was dropped and replaced by a lecture in an effort to improve student retention. The author of this study concluded the article with an excellent point:

> Different students have a "best way" of learning--for some it is the discussion group, for others the lecture, for still others self-study. The list is legion. What we need to do is to provide whatever method is best for the individual student (Hedrick, 1975, p. 65).

One of the most successful uses of programmed learning in chemistry has been carried out by Dr. R. L. Heider and Dr. Walter Hunter of Meramec Community College in St. Louis, Missouri. The method they used was called the "Systems Approach", an individualized programmed approach developed by Dr. Heider for the first-year premedical and pre-engineering chemistry students. The course material included textbook, workbook, student response book, exercises, audio-taped films, and testing materials. Lab experiments were an integral part of the program. Dr. Hunter completed an eleven unit study in which 180 students were divided into five different groups:

1. Individualized learning
2. Pre-test group
3. Learning theory group
4. Criterion Unit-test group
5. Lecture group

These groups were set up for the purpose of answering specific questions:

1. By which method of instruction will general chemistry students achieve the most?
2. Do pre-tests on unit objectives have any effect on achievement?
3. Will learning theory lectures (on how to learn) have any effect on achievement?
4. Will criterion evaluations of unit tests have any effect on achievement?

The study indicated that:

1. Students in the individualized learning groups achieved a significantly higher level on the final exam than students in the lecture treatment group.
2. Students' achievement in the individualized learning was significantly higher on only two of the unit test in the study.
3. Pre-testing on unit objectives resulted in significant achievement increase.
4. Criterion evaluations of unit test resulted in incremental achievement differences.
5. Learning theory lectures on how to learn have little effect on student achievement.

6. Students of either high scholastic ability or previous high academic achievement learned significantly more than students of low scholastic ability or low previous academic achievement (Hunter, 1973, p. 38).

The researcher felt the result of his study strongly supports the utilization of an individualized approach to general college chemistry. The individualized approach described by Hunter (1973) has most of the typical characteristics of programmed instruction as defined in this study. The instructional methodology used in Hunter's study is based primarily on the "Systems approach".

Summary

The search of the literature revealed that many comparative studies of PI and TI have been conducted. In this review no attempt was made to summarize and/or tabulate the total research on the subject. The examples were chosen from various fields and are believed to be typical of the total literature. This is particularly true in the area of science and chemistry. Other investigators have attempted to survey large portions of the literature on the evaluation and comparison of TI and PI. Three of these are included at this point.

A literature review by Lang (1972) showed that between 1960 and 1964 112 comparative studies of TI and PI were conducted to determine by which method achievement was higher. Forty-one percent showed PI to be superior, 49 no difference, and 10% found PI to be less effective than TI. Lang's survey also revealed that the amount of time needed to complete assignments with PI is usually less than with TI. Lang summarized the survey by stating:

> It appears, on the basis of the research to date, that it is reasonable to conclude that PI is generally as effective as TI and may result in decreasing the amount of time required for a student to achieve a specific educational goal (Lang, 1972, pp. 34-35).

Another survey of PI and TI was conducted by Schramumm (1964). This survey of thirty-six studies revealed that of the thirty-six, eighteen showed no significant difference in performance between PI and TI, seventeen showed a significant superiority for TI.

Another more recent survey by Hunter and Lingle (1976) of the nineteen-state region of the North Central Council of Community Junior Colleges indicates a strong belief by the practitioners of individualized instruction that achievement and student acceptance of individualized programmed instruction was superior to TI. This is summarized in the following table. Please note this data was tabulated from the opinions of the practitioners. The complete table is presented in the appendix as general information.

Table 7

PRACTITIONERS OPINION REGARDING INDIVIDUALIZED INSTRUCTION BY SUBJECT AREA

Subject	Cost-effective		Student Achievement		Student Preference	
	More	Less	Increased	Decreased	Yes	No
Humanities	39	43	78	0	74	0
Science	49	28	79	4	73	2
Math	51	19	83	4	70	9
Technical	66	17	86	4	71	10
Business	51	21	82	3	82	4
Social Studies	44	30	83	5	72	6
Health	63	16	90	0	73	10
Communications	46	21	84	3	71	7
Overall Average	52	23	84	2	74	7

(Hunter and Lingle, 1976, pp. 16-17)

This table indicates that the survey of professional people using individualized instruction believe that:

1. Individualized instruction is more expensive.
2. Achievement by individualized instruction is much greater.
3. Student predominantly prefer individualized instruction.

In summary, the literature review suggests no clear-cut superiority for either method of instruction in terms of achievement. It appears that PI is at least as effective as TI in terms of student achievement and may require less time to complete. It also appears that students may have a slight preference for PI, overall. Throughout the review, the problem of classification of the methods of instruction and the placing of them in the correct categories of PI and TI was noted. It is felt that this problem arises from a lack of standard definition by the researchers. As a result of this poorly defined classification of methods of PI and TI, some of the data and results may have questionable validity.

Chapter 3

MAJOR ISSUES - HYPOTHESES

Pilot Study

A pilot study was completed during the Winter Quarter, 1975, at CPCC (January 1 - March 30), a summary of which is included in this paper. The pilot study was made using material from module #4 of the MARP and, since it was felt that the pilot study made a substantial contribution to the MARP, the description and results of this study are included in the main body of this paper.

The purpose of the pilot study was:

1. To gather data to be used in formulating a hypotheses for the MARP.
2. To test the feasibility of the proposed MARP and to uncover any unforeseen problems that might arise.
3. To evaluate selected instruments to be utilized in the MARP such as the student evaluation questionnaire and pre- and post-tests.
4. To gather data on the problem to supplement the subsequent study.

The pilot study was concerned with a comparison of TI with PI for two similar units in general college chemistry. The purpose of the study was to determine:

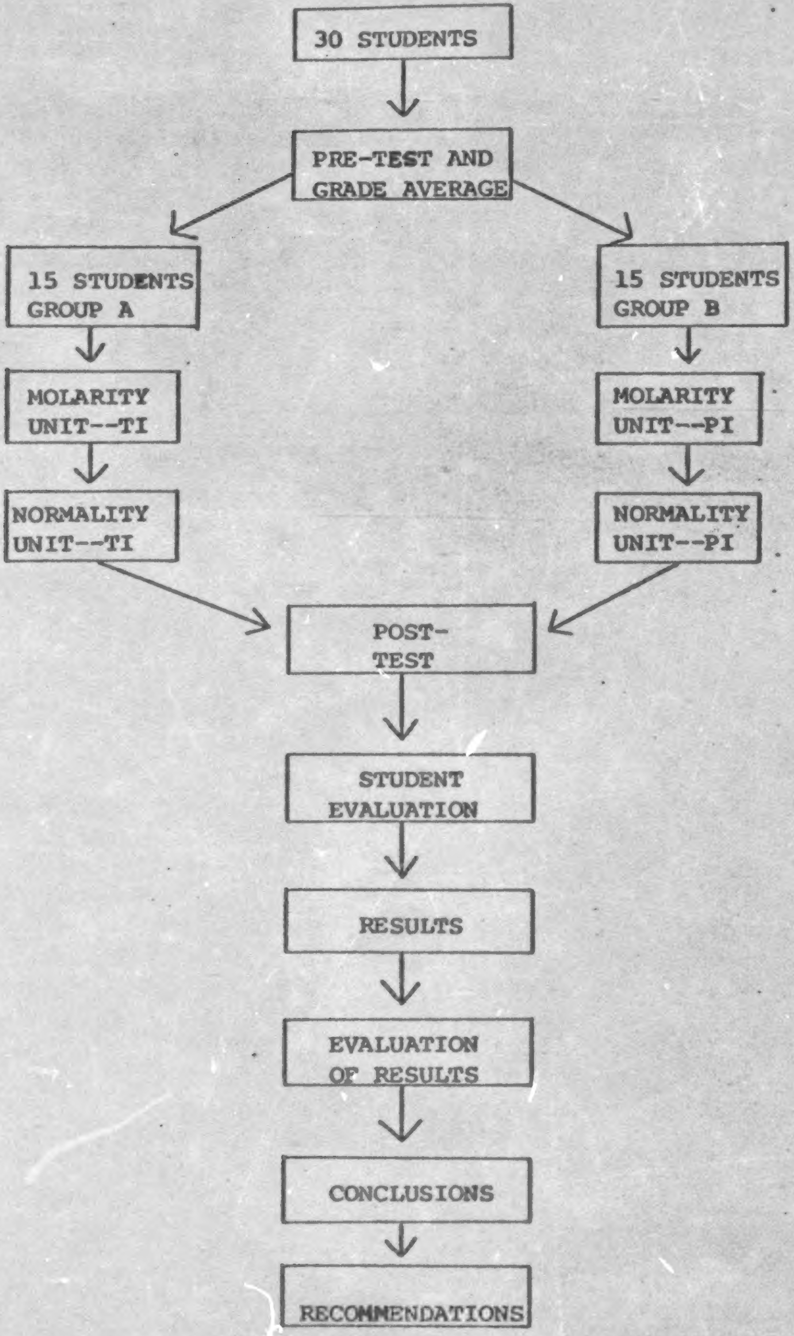
1. By which of the two methods of instruction will a

general chemistry college student achieve more, when given equivalent class time.

2. By which of the two methods of instruction will the student prefer to be taught, based on these units of study.

The pilot study differed from the MARP in that the class time used for both TI and PI were held constant. In the MARP study there was no time restriction made on PI (within reasonable limits). Students receiving PI in the pilot study were given the same amount of time on each unit as the student receiving TI. Students were not permitted to remove any tapes or written material from the PI lab or from the TI class except unit objectives and their own notes. A summary of this pilot study is included:

Diagram 2: FLOW DIAGRAM FOR PILOT STUDY


30 STUDENTS
PRE-TEST AND GRADE AVERAGE
15 STUDENTS GROUP A
15 STUDENTS GROUP B
MOLARITY UNIT--TI
MOLARITY UNIT--PI
NORMALITY UNIT--TI
NORMALITY UNIT--PI
POST-TEST
STUDENT EVALUATION
RESULTS
EVALUATION OF RESULTS
CONCLUSIONS
RECOMMENDATIONS

DESCRIPTION OF THE ACTIVITIES IN THE PILOT STUDY

1. A pre- and post-test were developed and then critiqued and checked by several advanced chemistry students and by two instructors. This material was also evaluated as excellent by Dr. Roueche, University of Texas. Criterion reference testing was used on the post-test. These tests were given for two reasons: (1) to aid in placing the 30 students into two equal groups, and (2) to measure the amount of learning that took place by both the lecture and programmed packages.

2. The population sample was selected from a general chemistry class at Central Piedmont Community College and placed into two equal groups on the basis of the pre-test score and on the basis of their class grade average up to that point.

3. The students in both groups were briefed at the same time on the purpose in conducting the study, and they were given the necessary background for the unit to assure that each student had equal footing in terms of what "he should now know."

4. The unit on molarity was taught to the two groups. One group used PI while the other group used TI with both groups given equal amounts of time. No participant was permitted to remove any tape or written material from the rooms.

5. The unit on normality was taught to the two groups, one using the PI approach and the other using the TI approach. In the second lesson, the method of instruction used on each group was switched so that both groups used both methods on two similar units.

6. Both groups were post-tested together to obtain gain scores. The post-test and pre-test had five questions on each of the two units, and the questions were designed to test the stated objectives in the two units; criterion-referenced.

7. "Item analysis" was run on both the results of pre-test and post-test to determine if they were good tests.

8. Students evaluated the lecture and programmed methods via a questionnaire. Again, the evaluation was made to assure that the quality of instruction was high for both methods, especially the lecture, since the

programmed method had been thoroughly evaluated before the study. The evaluation was important also to determine which method they preferred.

9. The results were summarized and treated.

DESCRIPTION OF LEARNING ENVIRONMENT FOR THE PILOT STUDY

Lecture

Fifteen students were taught in a typical classroom, using the chalk-board for problems, etc. The students were given a list of objectives along with practice exercises on a handout. Students showed much enthusiasm for the units in lecture and frequently became involved in open discussions. The lecture lasted about two hours for each topic. The total project time was two weeks.

Programmed

Fifteen students were taught by a written program in a room that had study carrels. Each student used the following items: (1) written program, and (2) cassette player with head set and tape. They were left with very little supervision--no help was given concerning the chemistry topics.

SUMMARY OF RESULTS (PILOT STUDY)

The data obtained from the study was treated as described below:

1. Item analysis was run on the pre- and post-tests.
2. The mean gain scores were determined for PI and TI.
3. The t-test was applied to the mean gain scores for all the students for PI and TI.

The average gain score found for the programmed instruction and the lecture instruction on each of the units is shown in the following table:

Table 8

AVERAGE GAIN SCORES ON EACH UNIT (PILOT STUDY)

	Molarity	Normality
Lecture	1.47	2.00
Program	1.87	2.07

The average gain score for both the molarity unit and the normality unit was higher for the programmed instruction.

The average gain score for both the units by each method of instruction is shown below:

Table 9

AVERAGE GAIN SCORE FOR BOTH UNITS (PILOT STUDY)

Method	Mean Gain Score
PI	1.97
TI	1.73

Again, the average for programmed method was higher than the average for the lecture method.

To determine if this difference in mean gain scores was significant, the t-test for the difference between means was applied.

It was found that at the 95% confidence level no significant difference exists between the mean gain score for PI and TI for these two units in chemistry.

A summary of student responses to the questionnaire is shown in Table 10 on the following page.

Table 10

STUDENT RESPONSES (Pilot Study)

	No	Yes	Percent Yes
1. Were the objectives clear for the unit taught by the lecture method?	3	26	89.6
2. Were the objectives clear for the unit taught by the programmed method?	2	27	93.1
3. Are you satisfied that you accomplished the objectives in the lecture unit?	7	22	75.8
4. Are you satisfied that you accomplished the objectives in the programmed unit?	9	20	68.9
5. Do you feel the objectives were covered adequately in the post-test?	2	27	93.1
	Lecture	Program	No Difference
6. Which unit had the clearest objectives?	7	7	15

The results of questions 1-6 indicate the students felt the objectives were clearly stated in both the lecture and in the programmed methods. A slightly larger percentage of the students felt they had accomplished more of the objectives in the lecture than in the programmed method.

Tables 11 and 12 show some important differences between the two methods. The differences shown in Items 13, 14, 21 and 24 were not surprising.

Table 11

STUDENT RESPONSE (Pilot Study)

Please fill in the following tables to record your personal reaction to both the lecture and programmed units. If your feeling is close to one of the words, mark space A or E in the table. If your feeling is neutral, mark space C. If your feeling is not extreme but strong, mark space B or D.

	A. Lecture Method	A	B	C	D	E	
7.	Worthless			5	12	12	Valuable
8.	Difficult			13	9	7	Easy
9.	Not Involved		4	10	13	2	Involved
10.	Unimportant		1	4	12	11	Important
11.	Dull	1	2	9	7	10	Interesting
12.	Useless			5	15	9	Useful
13.	Monotonous (Boring)		1	10	12	7	Varied
14.	Impersonal	1	4	6	14	5	Personal
15.	Unfair			8	8	13	Fair
16.	Ordinary	3	3	20	2	2	Far Out

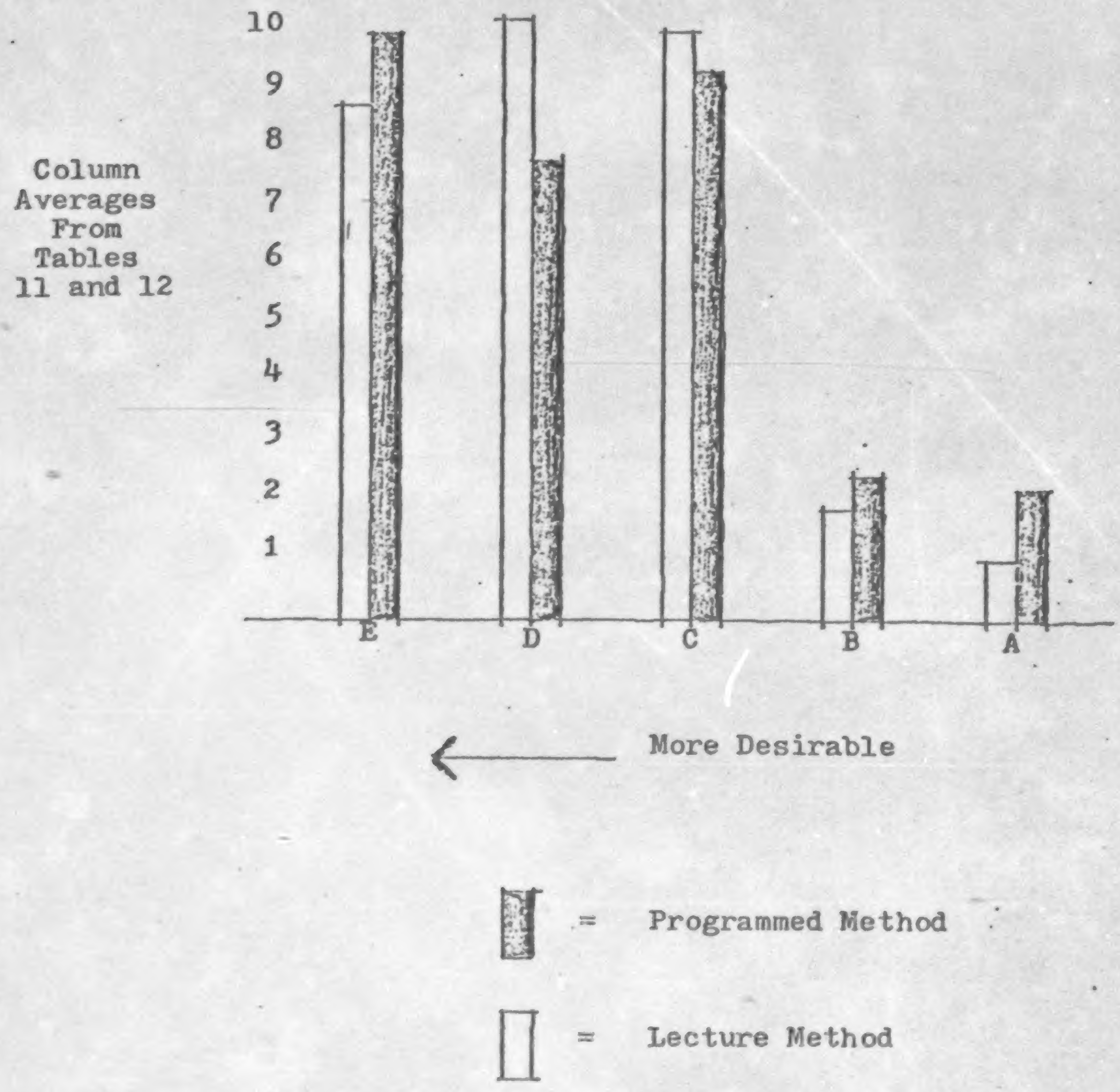
	B. Programmed Method	A	B	C	D	E	
17.	Worthless		1	2	11	15	Valuable
18.	Difficult		2	6	8	13	Easy
19.	Not Involved	3	2	10	11	3	Involved
20.	Unimportant		1	6	11	10	Important
21.	Dull	2	4	13	2	8	Interesting
22.	Useless			6	12	11	Useful
23.	Monotonous	2	6	10	6	5	Varied
24.	Impersonal	5	9	11	3	1	Personal
25.	Unfair			8	6	15	Fair
26.	Ordinary	3	2	15	4	5	Far Out

The lecture appears to be a little more interesting, varied, and personal. If the results in Table E were superimposed upon the results in Table F, it would appear that the students have a preference for the lecture method over the programmed method.

Graph A indicates the same overall student preference for the lecture method where the average for each column is plotted for each method.

Graph A

GRAPH OF AVERAGE RESPONSE FOR EACH METHOD VERSUS DESIRABILITY
(PILOT STUDY)



Other questions seem to verify the results shown on the above table, as indicated by the following table:

Table 12

STUDENT METHOD PREFERENCE (PILOT STUDY)

Lecture Method	35.4 Percent
Programmed Method	25.8 Percent
Some of Both	38.7 Percent

Some of the comments commonly made by students regarding what they like best about each of the two methods are listed below:

Programmed

1. "You can go over it again if you don't understand it at first."
2. "More organized."
3. "Program explained the problem step-by-step."
4. "You rewind the tapes and hear it again."
5. "Able to work at my own speed."
6. "Program was more logical."

Lecture

1. "You could ask questions and get more help from the teacher."
2. "More interesting."
3. "Teacher commands attention more than tapes do."
4. "Teacher's personality makes the class more interesting."
5. "After solving the problem or answering the question, the teacher can show me what I did wrong."

CONCLUSION (PILOT STUDY)

1. There was no significant difference in achievement when the two different methods of instruction were used for two very similar units in general chemistry where the amount of class and study time was constant. Three very important points should be noted concerning the two methods: (a) The student learned at least as much by the PI method as with the TI method without the presence of an instructor; (b) The development of the material used in the PI required much teaching experience and a large number of instructor hours; and (c) In this study the lecture was evaluated very highly whereas often this is not the case.

2. The students liked certain aspects of both methods of instruction although, overall, there was a slight preference for the traditional method. Most significantly, the students indicated a strong preference for using some of both methods.

Based on experiences with the pilot study, it was decided that the MARP was feasible and that no major problem should be encountered in the MARP. The necessity for a well-organized master plan for the MARP was realized in consideration of the numerous tasks to be performed in the study.

The data collected was found to be useful in formulating the hypotheses for the MARP and as a supplement to the data collected in the MARP. As will be observed later, the results of the pilot study were very similar to those of the MARP study with regard to student achievement but quite different with regard to student preference.

Hypotheses

1. Central Piedmont Community College general chemistry students of equal ability will have greater achievement when taught by partially adaptive PI than when taught by partially adaptive TI.
2. Central Piedmont Community College general chemistry students will prefer to be taught by partially adaptive TI rather than partially adaptive PI.
3. Central Piedmont Community College general chemistry students of lower reading ability will achieve more when taught by partially adaptive PI than by partially adaptive TI.

4. Central Piedmont Community College chemistry students of higher reading ability will achieve more when taught by partially adaptive TI than by partially adaptive PI.
5. There will be no significant difference in the quality of instruction presented in the TI units and the PI units based on the rating scale in the questionnaire.

Variables

Independent - Method of Instruction

Dependent - Achievement and preference of Method

Constant - CPCC students, task order, task content, student ability in chemistry, background in chemistry, reading ability, grades, age, sex, instructor, and adaptivity of methods.

Rationale for the Hypothesis

Previous studies in fields other than chemistry and many in chemistry have shown PI to be superior to TI in many instances. Programmed instruction is more organized and is designed with specific learning principles applied with directed outcomes. Programmed instruction, in most cases, demands that the learner achieve a certain level of competence before proceeding to new material. This is usually determined through the use of criterion referenced testing rather than norm referenced testing.

Programmed instruction focuses on the individual learner while the TI approach focuses on the learner in a group. Programmed instruction demands that the outcomes of learning, the objectives, be achieved by the student and, furthermore, that their learning goals be specified in detail prior to the unit. The fact that specific learning objectives are clearly defined in advance makes it possible to plan and design more efficient learning strategies in order to achieve these objectives. PI usually will accommodate individual differences more fully than TI by providing a variety of learning pathways using various delivery systems. Most programmed instruction provides ample student evaluation and other cyclic feedback which provides for constant evaluation and revision. TI usually does not have this built-in cyclic feedback revision process and even if it does, it is not usually done in a systematic way.

One of the most important differences between PI and TI is the role of the instructor. In PI, the instructor becomes more of a manager and a diagnostician with the emphasis on measurable student learning and not on teacher activity. Thus, PI should produce more learning since the emphasis is upon the accomplishment of measurable objectives by the student.

The learning environment for PI may or may not be highly structured but is generally less structured than TI requiring the student to set his own pace and to select the delivery system to be used. Again, the emphasis is on the student learning rather than the instructor teaching. Grading systems encountered in TI usually involve A, B, C, D and F and students may view this system as punitive, because the individual may be punished for not completing the course in the prescribed time. Experience in the teaching of chemistry indicates that students achieve more when they can concentrate upon the basics of chemistry and not the grade to be attained. A typical grading system where PI is used will include A, B, C and I (or pass, fail)--a non-punitive system with respect to time. If a student does not fulfill a large proportion of the course goals, he is given a grade of I and permitted to complete the course in a longer period of time determined by the student and teacher. This type of system focuses on achievement of the stated objectives. TI places greater emphasis on grading rather than learning. This has been noted in student-to-student conversation in which they are much more likely to evaluate PI by "what I learned" rather than by "the grade I made".

The average grade in General Chemistry at CPCC has been estimated to have increased by at least a letter grade, from a C to a B, since PI has been used in the course. (This cannot be attributed to grade inflation because A.C.S. exam scores have also increased.) In addition, the number of students who successfully completed the course has also increased, from about 50% to 70%. Both of these observations suggest that students are achieving more under PI. Students in other areas of the school have shown greater success using PI than TI in such courses as Shop Science and Technical Physics (PSI).

As has been illustrated, TI may be highly adaptive and may include many of the desired features of programmed instruction. In most cases, however, it does not. TI is usually not as well organized as PI and lacks the systematic approach with the application of learning principles. As a result, it is believed that more learning will take place in General Chemistry using PI than using TI.

An advantage of TI is that the instructor can adapt the learning situation to meet the immediate needs of the class. In this way, the instructor serves as a feedback--change agent. TI has, as the center of learning, the instructor, who is live and can be much more stimulating than a programmed book, audio tape, etc. The teacher can talk back to the student and answer questions. In most cases, the instructor is available as a source of encouragement and should motivate the student through counsel and personal contact, albeit limited. Most students are accustomed to TI and many need a "live" instructor for varying reasons. It is predicted that, in the majority of instances, the students will prefer TI to PI if given only one choice of instruction. It is expected that many students will see advantages in both methods and that most will prefer the use of both.

The pilot study indicated that students learn just as well, or slightly better, by PI as by TI on a module similar to those used in the MARP even though the amount of time spent by each TI and PI section was held constant on both units in the pilot study. One of the major advantages of PI is its inherent self-pacing which gives the student as much time as he needs, within limits.

In the MARP, students in PI were given reasonably unlimited study time. While students in the TI section were given unlimited study time also, they were limited in the amount of time in which they had access to the instructor (the main information source). Since the PI group in the pilot study achieved just as much within a limited time as the TI group, one might expect them to achieve more if given unlimited time using the programmed materials.

The pilot study also revealed that students were pleased with PI but, when asked which method would they prefer if given a choice based on the module completed, they chose TI. This was not too surprising considering results of other research studies presented. Connally and Sepe (1972) found that only 50% of the students preferred the individualized to the traditional approach. Yet, a majority of the students indicated a preference for most of the characteristics of individualized instruction except that they preferred teacher control rather than student control of the learning situation. Evidently, students do not want to accept the complete responsibility for learning and, as a result, chose TI.

One of the basic assumptions in developing programmed instruction in chemistry at CPCC was that students with inadequate educational experience in chemistry could achieve more with PI than with TI. The most basic tool needed for learning in school has been shown to be reading ability. Therefore, it was decided that a comparison be made between higher and lower reading groups taught by TI and PI to determine by which method each group achieved more. The usefulness of this knowledge is obvious. The statement of the directional hypothesis concerning the achievement and reading ability was based on the above assumption.

Although the writer believed that programmed instruction is superior to traditional instruction in many ways and had predicted that most students, however, would prefer the time-tested traditional approach, the study was conducted in a highly scientific manner. Observations and conclusions were made in an unbiased fashion and are stated honestly in the final report. Evidence of this is shown by the "Certification of Data Validity by Sanders" included in the appendix.

Operational Definitions of the Variables

Partially Adaptive Traditional Instruction - Teaching and learning where the instructor is present in a classroom or lab with students for a scheduled period of time. The instructor is the center of learning, doing most of the talking and/or writing. Due to the constraint of time, learning is usually lock-step with limited self-pacing.

individualized instruction. Specific learning objectives may or may not be stated; in most cases they are not. (They are stated in this study in all of the modules.) The instructor is alert to the class needs and is constantly adjusting the instruction to meet the needs of the class with limited time for individual help.

Partially Adaptive Programmed Instruction - Instruction where the instructor may or may not be present in person during the learning activity. Detailed learning steps are provided for the student using various delivery systems such as written materials, audio tapes, video tapes, sound-on-slides, etc. Learning is not lock-step and each person progresses at his own rate of learning (within certain limitations). Specific learning objectives are always stated with frequent evaluation using criterion referenced testing.

Achievement - Average gain scores on post-test for each of the methods on each of the units (to be significant $p < .01$).

General Chemistry Student - Any student officially registered for Chemistry 1504, 1505, or 1506 at Central Piedmont Community College. (See appendix for course descriptions).

Equal Ability in Chemistry - Determined by previous background in chemistry and from scores on the Toledo Placement Test.

Student Preference - Method of instruction (TI or PI) students prefer as determined from a questionnaire and chi-square analysis of the rating distribution for TI and PI (to be significant $p < 0.01$).

Reading Ability - As determined from scores on the Nelson Denny Reading Test.

Quality of Instruction - As determined by the results of student evaluation of methods (to be significant $p < 0.01$).

Chapter 4

PROCEDURE AND METHODOLOGY

Subjects

The students selected for this study came from first quarter general chemistry classes at CPCC. The number of students involved ranged from 90 at the beginning to 60 at the conclusion of the 1504, 1505 and 1506 general chemistry sequence. Students comprising the group were characterized by having many and varied backgrounds and an age range of nineteen to thirty-five, with a mean age of twenty-two.

Approximately eighty percent were from the college transfer area and the remainder from the technology areas (chemical, electrical, mechanical, etc.). The group members were considered to be representative of "typical" CPCC general chemistry students. A summary of their characteristics are presented in Table 14.

The students were divided into two groups, each with equal learning ability in Chemistry as indicated by scores on the Toledo Placement Test (Form C) and by previous grades in Chemistry and science. As shown in Table 14, the two groups were similar with respect to age, sex, veteran status, previous courses and grades in chemistry and science, and professional ambitions.

Table 13

CHARACTERISTICS OF THE SUBJECTS

	Group A	Group B
Number at the beginning of study	45	45
Number of Veterans	8	9
Percent Veterans	22	25
Number Non-Veterans	37	36
Male/Female Ratio	2.7/1	2.0/1
Average previous math	2.36 yrs.	2.36 yrs.
Estimated grade in previous math	B	B
Average previous physics	0.57 yrs.	0.60 yrs.
Estimated grade in previous physics	C	C
Average previous chemistry	0.81 yrs.	0.76 yrs.
Estimated grade in previous chemistry	B	B
Mean score on Toledo placement test	32.2	34.3
Median score on Toledo Placement Test	33	33
Educational Goals		
Medical Profession	25%	30%
Science Major (Biology, Chemistry, etc.)	21%	20%
Technology	10%	11%
Engineering	15%	17%
Business Economy	7%	4%
Undecided	21%	18%

The total group of students was also divided into a high reading group (R_H) and a low reading group (R_L), the division being made on the basis of scores from the Nelson Denny Reading Test. The rationale for this separation into high and low groups was to investigate the relationship between reading ability and achievement by PI and TI in general chemistry. Students who scored above the 52 percentile on the reading test were assigned to the R_H group, while those below the 52 percentile were placed in the R_L group. (These percentile scores were not based on Table 14.) Students who had been given other reading tests or a different form of the Nelson Denny Test were not included in either group. Hence, the number of students comprising the A and B groups was greater than the number in the R_H and R_L groups. Twenty-six (26) students were assigned to the R_H group and twenty-eight (28) to the R_L group.

It is believed that students enrolled in general college chemistry at CPCC are, on the average, better prepared mathematically and are higher achievers than the general population of students at CPCC.

A possible indicator of ability to achieve more is the higher median score (52 percentile) for this group as compared with the median score for the college transfer student at CPCC. According to Griffin (1976) 46% of the college transfer students scored below the twelth grade level.

Research Design

The experimental design for this study was the Quasi-Experimental type--non-equivalent control group as described by Tuckman (1972).

Diagram 3

RESEARCH DESIGN

$$\begin{array}{ccccc} O_1 & X_1 & O_1 & X_3 & O_3 \\ \hdashline O_2 & X_2 & O_2 & X_4 & O_4 \end{array}$$

O_1 = Pretest Group A
O_2 = Pretest Group B
X_1 = PI Treatment Unit #1 for Group A
X_2 = TI Treatment Unit #1 for Group B
X_3 = TI Treatment Unit #2 for Group A
X_4 = PI Treatment Unit #2 for Group B
O_1&O_2 = Post-test Unit #1 for both groups.
O_3&O_4 = Post-test Unit #2 for both groups.

This design is similar to the pretest/post-test control group except for the random assignment of subjects to each group. The true research design requires that the sample be selected from the total population on a completely random basis. This comparative study of TI and PI used students from intact-groups (classes) which were not randomly assigned and, therefore, were placed into the Quasi-experimental design (Tuckman, 1972, p. 118).

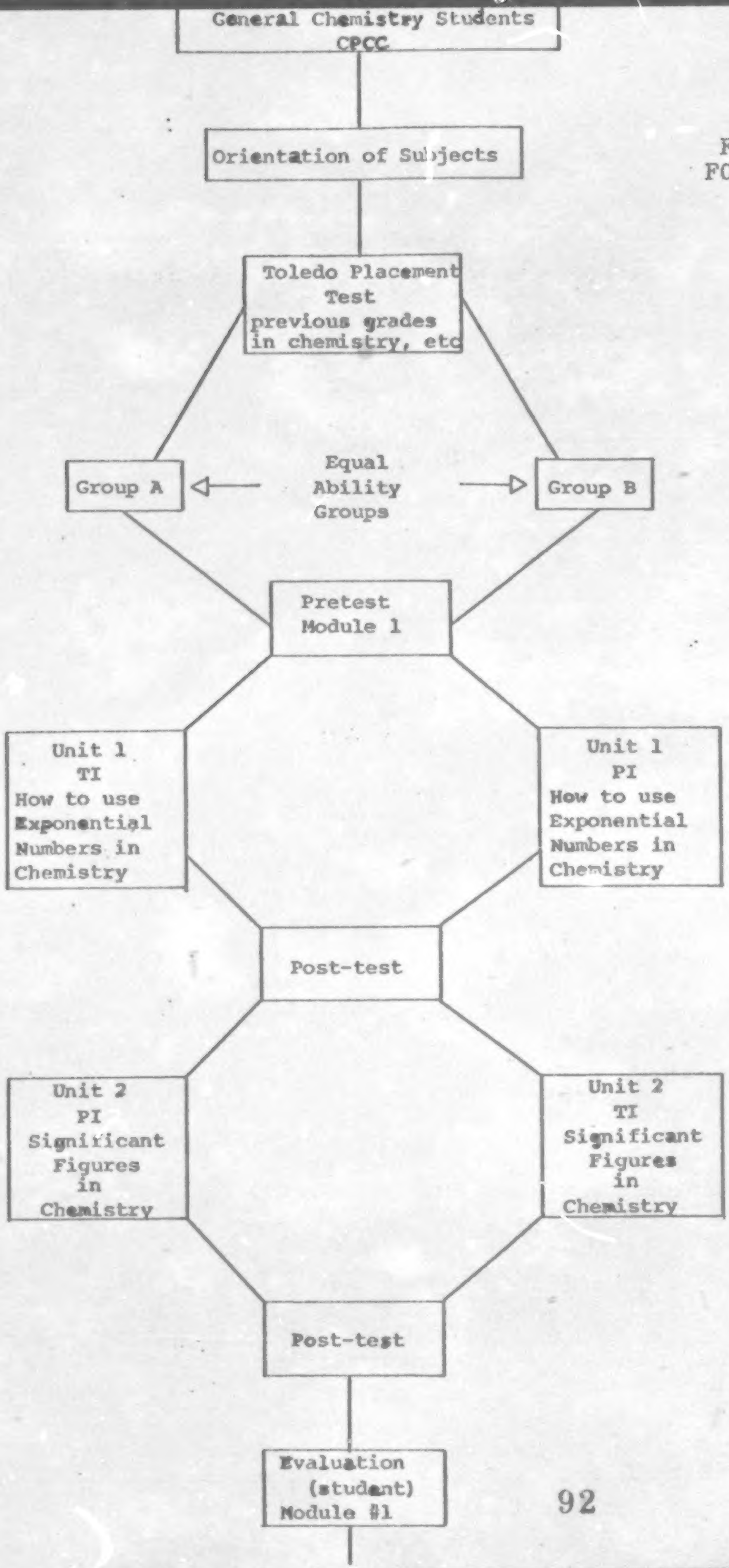
Because the subjects could not be randomly assigned to the groups, a pretest was given before the assignments were made to insure equivalence of the groups. The Toledo Chemistry Placement Examination was used for this purpose. In addition, other factors related to achievement such as grades in previous science and chemistry courses, ages, sex, etc., were ascertained. All of these, plus the placement test, were used to assign the subjects to two groups having relatively equal ability. (See Table 1)

Procedure and Rationale for Activities

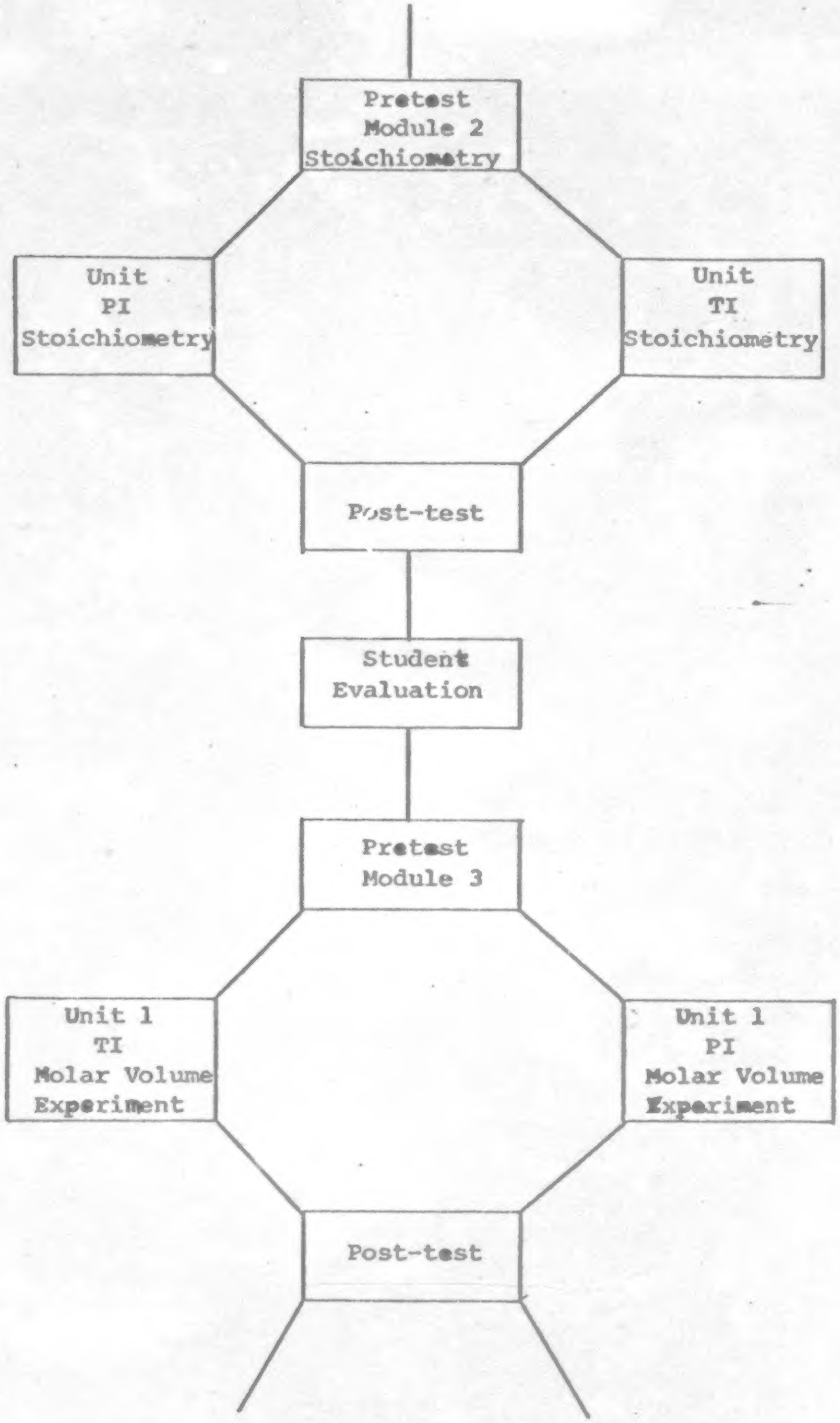
The study was divided into five modules each composed of two similar units (with the exception of one which contained only one unit). A pretest was given at the beginning of each module, followed by Unit One of that module with one group receiving the TI treatment while the other group received the PI treatment. This was followed by a post-test on Unit One of the module. In the second unit of each module, the groups were given the reverse treatment; that is, if Group A received the TI treatment in the first unit, Group A received the PI treatment in the second unit. The completion of the second unit was followed by another post-test and a student evaluation of both units one and two of the module. The average gain score obtained by each method for each unit was student evaluations summarized for TI and PI on each module, and the overall average gain scores were tabulated for TI and PI for the high and low reading groups.

Diagram 4

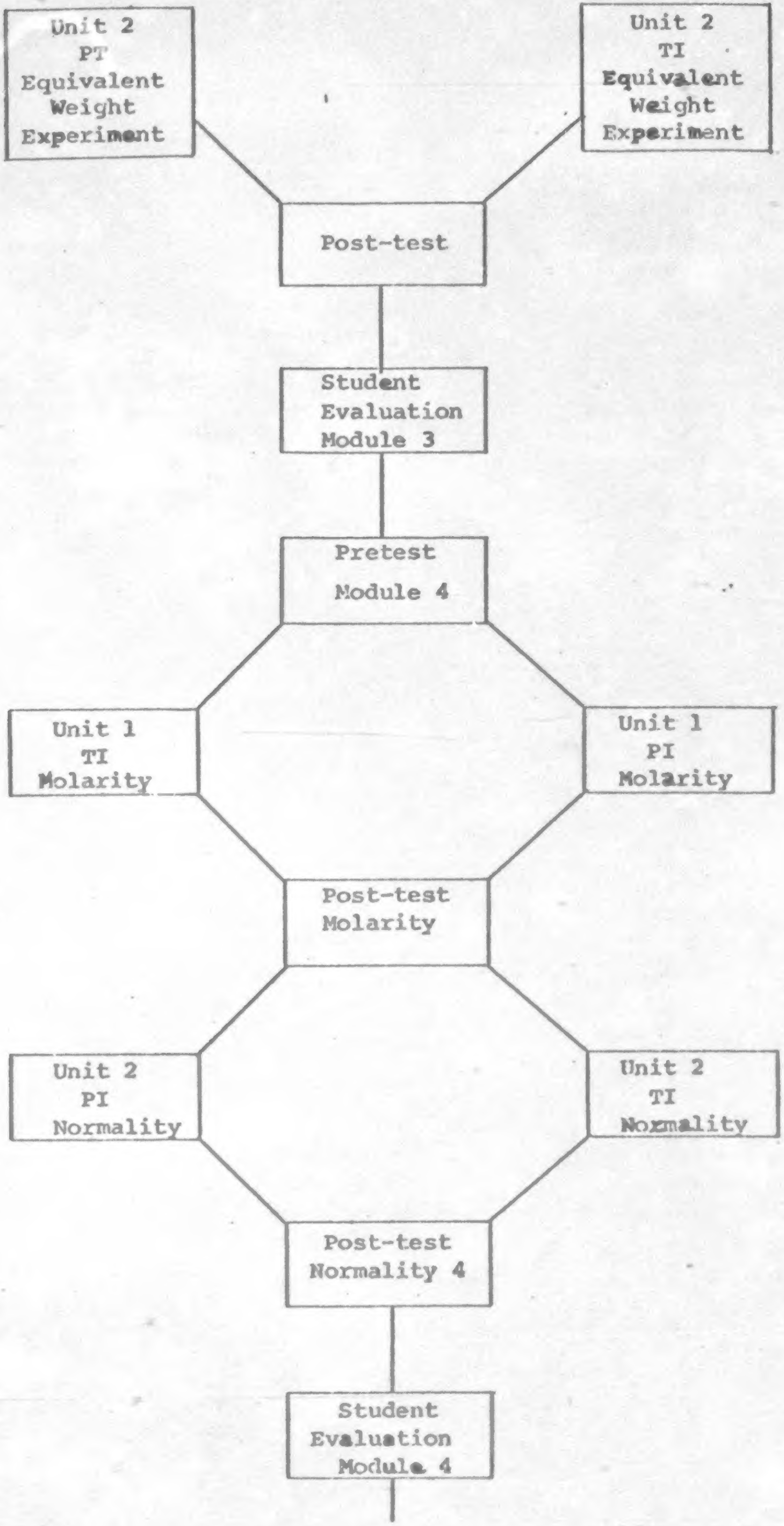
FLOW DIAGRAM FOR THE STUDY


General Chemistry Students
CPCC
Orientation of Subjects
Toledo Placement Test
previous grades in chemistry, etc
Group A
Equal Ability Groups
Group B
Pretest Module 1
Unit 1 TI How to use Exponential Numbers in Chemistry
Unit 1 PI How to use Exponential Numbers in Chemistry
Post-test
Unit 2 PI Significant Figures in Chemistry
Unit 2 TI Significant Figures in Chemistry
Post-test
Evaluation (student) Module #1

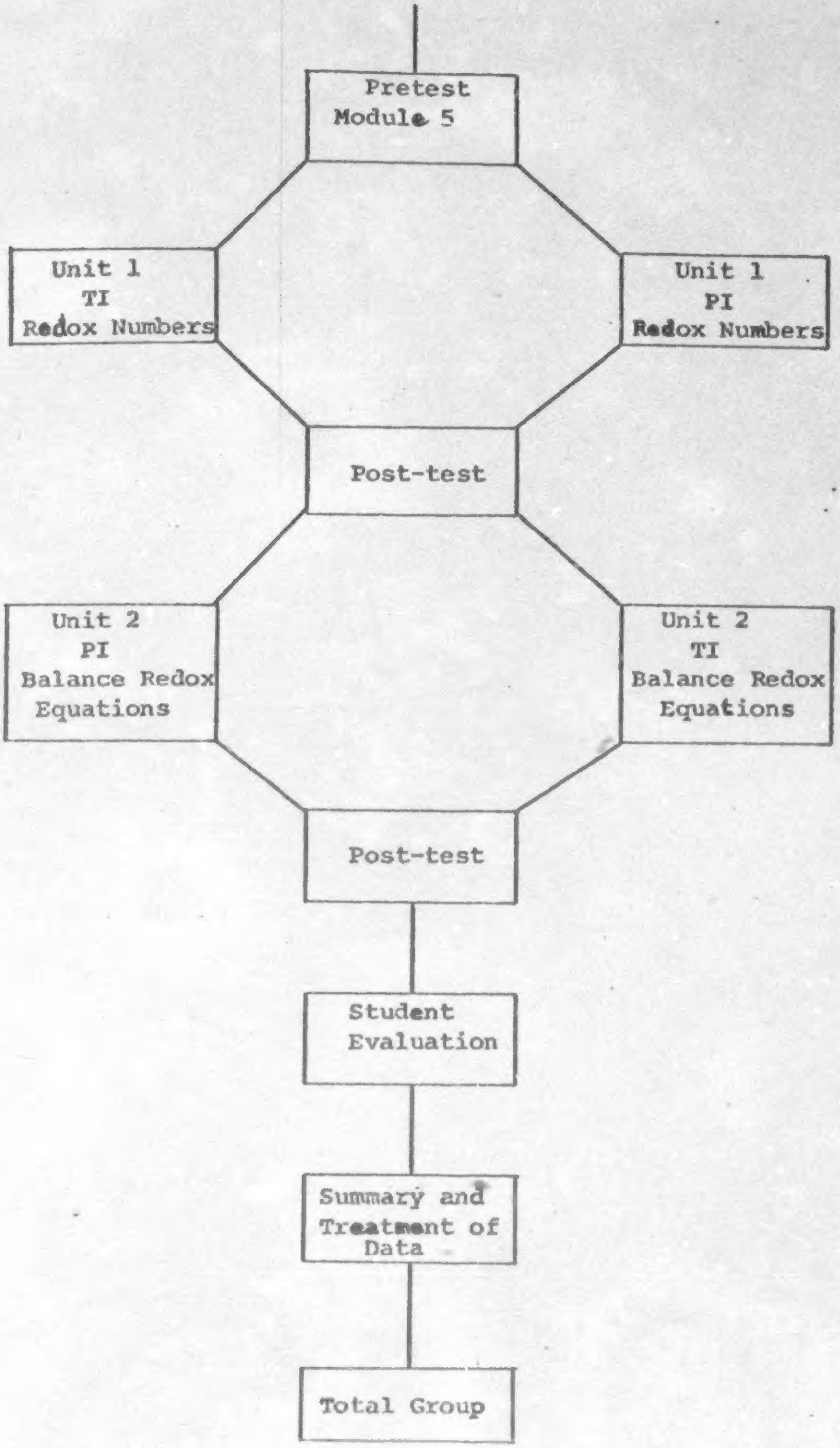
FLOW DIAGRAM FOR THE STUDY CONTINUED


Pretest
Module 2
Stoichiometry
Unit
PI
Stoichiometry
Unit
TI
Stoichiometry
Post-test
Student
Evaluation
Pretest
Module 3
Unit 1
TI
Molar Volume
Experiment
Unit 1
PI
Molar Volume
Experiment
Post-test

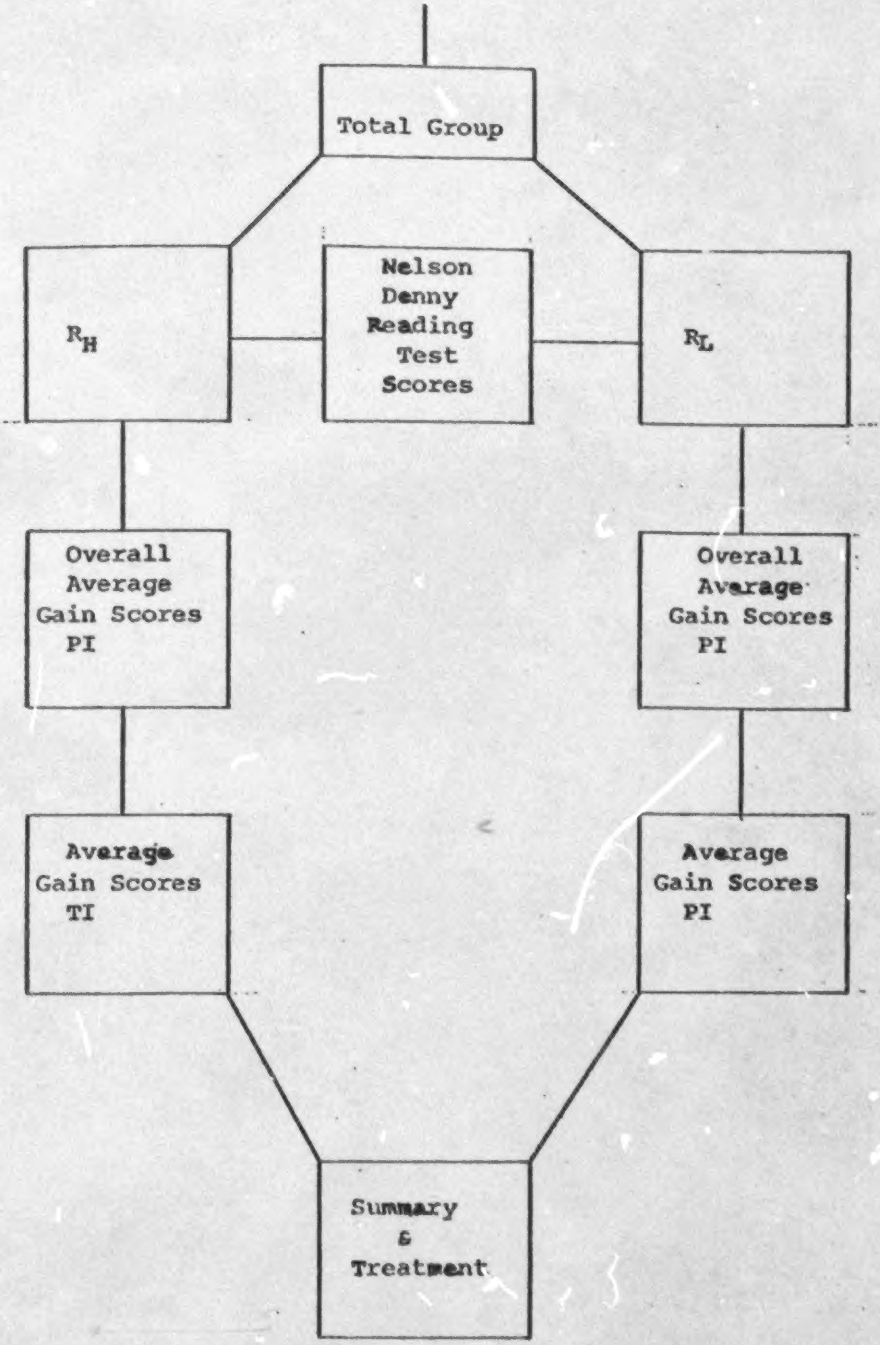
FLOW DIAGRAM FOR THE STUDY CONTINUED


Unit 2 PT Equivalent Weight Experiment
Unit 2 TI Equivalent Weight Experiment
Post-test
Student Evaluation Module 3
Pretest Module 4
Unit 1 TI Molarity
Unit 1 PI Molarity
Post-test Molarity
Unit 2 PI Normality
Unit 2 TI Normality
Post-test Normality 4
Student Evaluation Module 4

FLOW DIAGRAM FOR THE STUDY CONTINUED


Pretest
Module 5
Unit 1
TI
Redox Numbers
Unit 1
PI
Redox Numbers
Post-test
Unit 2
PI
Balance Redox Equations
Unit 2
TI
Balance Redox Equations
Post-test
Student Evaluation
Summary and Treatment of Data
Total Group

FLOW DIAGRAM FOR THE STUDY CONTINUED


Total Group
R_H
Nelson Denny Reading Test Scores
R_L
Overall Average Gain Scores PI
Overall Average Gain Scores PI
Average Gain Scores TI
Average Gain Scores PI
Summary & Treatment

Programmed units from the general chemistry course were selected as the topics to be used in the study. These programs were written by the author and class-tested several times at Central CPCC. They were subsequently published and adapted as one of the texts used in the freshman chemistry course at CPCC. (For an example, see appendix.)

The programmed units usually follow the following outline: Introduction, pretest, specific objectives, summary of tasks, detailed learning steps to achieve the stated objectives, and post-test (Cheek, 1972). The total instructional package may include filmstrips, films, and video tapes. However, usually it consists mostly of written material and cassette tapes. As can be seen, the written material requires frequent student response with review. The audio tapes serve as a supplement to the written material and supply the student with detailed answers to many questions posed in the program and with additional information about the topics not included in the written material. Audio tapes are very commonly used with this type of instruction at Central Piedmont Community College, and many students find the tapes very helpful. Data collected indicates that approximately seventy percent of the students taking general chemistry at Central Piedmont Community College choose to use the tapes from the library in addition to those being used in the chemistry lab.

These programmed units were the product of many years of teaching chemistry and of specialized training in the writing of programmed materials. The eclectic approach was used in writing the program using a combination of the Systems approach and Cistran (Deterline and Lenn, 1972). Literature review shows that the difference between the various approaches is not great. The packages used vary somewhat in their format, but basically they are quite similar. The order in which the components of each package were developed are as follows:

a. Self-evaluation - (Test)
b. Objectives
c. Discussion of self-evaluation - (answers to test)
d. Practice exercise items - (learning exercises)
e. Discussion of practice exercises - (answers to practice exercises)
f. Study Review
g. Introduction

One of the strong points of the above sequence of development is that the test was written before the objectives. This results in a double emphasis on objectives and test in the composition of material that answers the test items and objectives--a subtle but, never-the-less, important approach.

The subjects were given the written material and cassette tapes for each PI unit assigned. Information was given concerning the location of related material for each unit. For example, many supplementary audio-visual materials such as filmstrips, books, filmloops, and films were found in the open chemistry lab. (This information is actually a part of the written program.) The students were not allowed to attend class during the PI units and they were given as much time (within certain limits) as they desired to complete each unit. Students were encouraged to make use of the open chemistry lab and/or the study carrells (which contain headsets and cassette players) in the library. The PI units were almost complete self-paced. Participants were requested to keep a record of the amount of time spent on each unit for the purpose of comparison with TI. It was emphasized to the participants that they could complete the PI units anywhere they wanted, whether at home, at Central Piedmont Community College, or even on their way to school or work or on a part-time job. (Students have reported diverse study patterns.) It was emphasized, too, that if PI were followed closely, they should need little help from the instructor or from other students. Students using PI units were allowed to seek help from the instructor, if needed, but it was expected that little help would be requested.

The TI units were taught in the "usual" way by the author. The class met for a definite period of time (three days per week, excluding labs) with the instructor leading the class discussion, asking questions, lecturing, using the chalkboard or charts, etc. Classes taught by TI in this study were more structured than the typical "lecture" class. For example, specific learning objectives were given to the TI groups and pre-test and post-test were a part of each module. In most traditionally taught classes, tests are not given as frequently as was required in this study nor are students given specific learning objectives or pre-tests. The administration of both pre- and post-tests and the use of learning objectives were required for a meaningful and valid study. Students in both groups needed to know what was expected of them, if a scientific comparison were to be made.

TI was textbook oriented with class notes written on the blackboard and/or given to the student as a handout. An effort was made to adapt TI to the needs of the students by actively encouraging participation in the form of questions and discussion. A review was given of the information necessary to make assigned topics understandable and homework assignments were made from the textbook. Thus, the TI group was taught in a partially adaptive fashion, as was the PI group. Subjects using the TI units did not have access to the programmed materials, requiring that they learn by TI when assigned to units taught by this method of instruction. Students were requested to keep a record of time spent on homework for each unit so that this time could be compared with the time using PI. A summary of the contrasting properties of the two methods of instruction are shown in Table 15.

As one can see from the flow diagram, five of the modules contained two matched units of study, with each group (A and B) being taught the same units at the same time by two different methods. (It was impossible to match all units.)

In the subsequent unit of each module, the method of instruction was switched. To help rule out any effect of order of treatment (of TI and PI) on the gain scores on each module, the order of receiving the TI and PI treatment was reversed after each module. This pairing of the two matched units allowed each group to be exposed to both treatments in each module with the matched units. The two units in each module were matched on the basis of length, similarity and degree of difficulty. It was believed that this matching of units for the PI and TI treatment of each group in each module would greatly enhance the internal validity of the study.

A pre-test was given at the beginning of each module to ascertain the knowledge of each group before it received the treatments. A post-test was given at the end of each module to measure the achievement on each unit. Average "gain scores" were computed from the pre-test/post-test scores for each method of instruction and the average gain scores were tabulated for all of the modules.

The units selected for the study varied from detailed mathematical calculations used in chemistry to two lab experiments and were taken from all three courses in general chemistry. It was impossible to include a "whole course" in the manner described and, as a result; units were selected that **were** considered to be representative. The total amount of class time devoted to this study was about forty class hours (greater than one quarter of classwork) and involved 90 students. It was felt that forty class hours with the involvement of 90 students should yield ample and adequate reliable data for the study.

One of the main thrusts of the study was to determine the preference--choice of method of instruction--of the students. To do this, a questionnaire was developed to obtain this information, in addition to other pertinent data. This questionnaire had been used and revised in two previous studies, yielding satisfactory results. (See pilot study) In these studies the students appeared to understand the questions well, resulting in very few unanswered and/or misunderstood responses. The questionnaire proved to be adequate in the pilot study. As a result, it was felt that this instrument should be valid and reliable for this study. Proof was needed that both the TI and PI instruction was presented on such a level as to yield valid results. This was especially true for the lecture (TI) since much of the PI has been thoroughly evaluated before. Another important aspect of the questionnaire was the determination of the extent that the participants felt they had achieved the stated objectives for each of the units taught by TI and PI.

Thus, an evaluation was made for each method of instruction with respect to.

1. the effectiveness of the method in helping the subjects achieve the objectives and
2. how the subjects felt about that particular method.

Table 14

COMPARATIVE TABLE OF TI AND PI

TI	PI
Closed Class	Open Class
Limited class time	Unlimited study time
Stated objectives	Stated objectives
Pre-test - Post-test	Pre-test - Post-test
Learning steps not greatly detailed with random student response.	Detailed learning steps with frequent well planned student response.
Teaching and learning closely controlled directly by the instructor.	Teaching and learning controlled indirectly by the instructor through written programs and audio-tapes but with student control overall.
Some individual help given by instructor.	Little individual help given by instructor.
Partially adaptive	Partial adaptive
Instruction	Instructional material
Few alternate learning pathways made available.	Some alternate learning pathways made available.
Focus is on the learner in a group.	Focus is on the individual learner.

Validity and Reliability of the Tests

The Toledo Placement Exam (Form 1967) was developed for the purpose of having available a one-hour chemistry test that could predict, with a high degree of accuracy, the future success of a beginning student in a general chemistry course. This test was used at Central Piedmont Community College, at other local community colleges and at the University of North

Carolina at Charlotte in a study (unpublished) comparing the general level of achievement of incoming freshman chemistry students. The portion of the study dealing with Central Piedmont Community College students indicated that the Toledo Placement Test (TCPE) was a valid predictor of the future success of the chemistry student. Those students who did well on the TCPE also did well in their general chemistry courses (Cheek, 1972).

The reliability coefficient for the TCPE (Form 1967) was found to be 0.921 as estimated by means of the Kuder-Richardson formula 21. This value indicates the test had good reliability. The spread of responses in the lower range indicates that incorrect answers are well written. (See appendix) The item-discrimination indices are high as shown by the following data:

Table 15

DISCRIMINATION INDEX ITEMS

50-49	67	20	outstanding
49-49	25	18	very good
30-39	18		------
0-30	4		unaccepted

(Hovey and Krohn, 1963, p. 370)

The validity of TCPE has proved to be very satisfactory in that most students scoring above the cut-off score of forty are successful in Chemistry 117 at Toledo University. A summary of this data is shown in the appendix. The number of F grades decreased from over thirty-four percent to less than ten percent after the TCPE was used at the University of Toledo. In the opinion of the authors of the test, it has been an excellent tool for determining which students should be enrolled in a remedial course (Hovey and Krohn, 1963).

A comparison of the course grades and TCPE scores in eleven different community colleges in California was made with those at Toledo University. (See appendix) As might be expected, the community college TCPE scores are lower with a slightly lower letter grade for the courses. It does appear that students who scored less than forty on the TCPE have little chance of being successful in the later chemistry courses in both the community college and at the University of Toledo.

One of the criticisms of the TCPE has been that the statistical data used to validate the test came from two-thousand students at the University of Toledo, only (Crawford, 1965). This appears to be a legitimate criticism. However, the TCPE has been used by eleven community colleges in California, and some corroborating statistical data has been collected.

An item by item inspection and evaluation of the TCPE in terms of the chemistry course at Central Piedmont Community College shows the test to have high content validity. Most of the problem solving skills and general knowledge on the list are included in the general chemistry course content. Further analysis of the TCPE in terms of the course objectives indicates that the test has good criterion related validity. It appears that the test measures the skills and knowledge the course objectives define as being important.

In consideration of the facts and opinions concerning the TCPE and the constraints of time, economics, and the familiarity and availability of the test, it was believed that the TCPE was suitable for this study.

Reading ability was determined by the students scores on the Nelson-Denny Reading Test, Form C (1973). The following evidence substantiates the use of this test. Research has shown a close relationship between scholastic achievement and scores on reading tests such as the Nelson-Denny Reading Test. Gusluin (1965) has shown that there exists a close relationship between scores on reading tests and the success or failure of nursing students. Garrett (1949) summarized 57 reported correlations between scholastic achievement and reading scores in specific subject matter fields. Coefficients ranged from .10 to .70, with a median of .40. The Nelson-Denny Reading Test showed a correlation of .67 with achievement in one of these studies.

Joyner (1972) concluded that "there is a significant relationship between the 'total' Nelson-Denny percentile tank scores and cumulative first-year grade point averages of 181 selected Afro-American male and female freshmen students."

See Tables 17 - 21 in the Appendix for specific correlations of the Nelson-Denny Test with other predictors, for the split-half reliability coefficients, and for the test-retest reliability coefficients.

Considering the correlation between the scores on the Nelson-Denny Reading test and achievement, grade point average, and scores on the Minnesota Scholastic Aptitude Test (MSAT), the Nelson-Denny Reading Test was considered a valid measure of reading and learning ability. The high test-retest reliability coefficient for the Nelson-Denny reading test indicated the test was reliable.

The pre-test and post-test to be used in this study were teacher-made. Different forms of similar tests have been class-tested at Central Piedmont Community College for the last three years and are estimated to have good reliability and validity. Students have shown consistency in their performances on these tests with the majority of the percentage scores ranging from sixty percent to ninety percent on the post-test with an average grade of about eighty percent. The tests are multiple choice and objective with no penalty for guessing enforced. The test items are criterion-referenced and are written in terms of the unit objectives with at least two questions written for each of the objectives. The test items are written according to most of the "good" principles of test construction cited by Green (1963). For the most part, these tests are valid, reliable, usable, simple, clear and explicit. The tests are criterion-referenced, not power tests. They are written to measure the stated objectives in the unit and not to measure such things as reading rate, reading comprehension and/or intelligence. They are designed to measure the chemistry achievement as stated in the objectives.

Internal validity is estimated to be high due to the past performance by the student on the post-test. It is also believed that external validity is high due to the student's performance on the American Chemical Society general chemistry exam (ACS) given at the end of the course. Over the last four years, the mean scores have been in the middle range of the national norms. Students that perform well on the unit post-test also do well on the ACS exams.

Data Analysis

The mean gain scores were determined for the students, both TI and PI, for each module in the study and treated statistically. The t-test was used to determine if any difference in the mean gain scores for each module were significant.

Student responses to the questionnaire were compiled, and the data from parts II and III dealing with specific aspects of instruction were treated statistically. Chi-square analysis was run on the frequency of responses for each characteristic to determine if there were a significant difference between how the students felt about the two methods of instruction (see questionnaire in appendix).

Using part I of the questionnaire, a tabulation was made of how well students felt they had achieved the stated objectives in each module and appropriate comparisons were made. Other data from part I, dealing with the procedures used in the respective methods to attain the stated objective, were tabulated and compared.

From part IV of the questionnaire, a summary of what the students liked most and least about each method was made and used for comparison. The most important item by far, also on part IV of the questionnaire, was "which method do you prefer.......based on this unit or module?" The answers to this important question were tabulated for PI and for TI and compared for all of the modules in the study.

To compare the achievement of the reading groups by PI and TI, the following analyses were run. An average of all the mean gain scores for students on both TI and PI were computed for the high reading group. An average of all the mean gain scores for students on both TI and PI were also computed for the low reading group. The t-test was administered to determine if any difference in the mean gain scores were significant for either the high or the low reading group.

To ascertain if the two groups were treated with equal instructional quality, a 2 x 5 Chi-square analysis of the rating frequency was run on the data from part I of the student evaluation questionnaire. The specific pairs of questions and the rating scales are shown:

(1) Were the objectives clear for the unit taught by TI?

Yes 5 4 3 2 1 No

(2) Were the objectives clear for the unit taught by PI?

Yes 5 4 3 2 1 No

(3) Are you satisfied that you accomplished the objectives in the TI unit?

Yes 5 4 3 2 1 No

(4) Are you satisfied that you accomplished the objectives in the PI unit?

Yes 5 4 3 2 1 No

(5) Do you feel the material used and procedures followed in the TI unit were adequate to achieve the stated objectives?

Yes 5 4 3 2 1 No

(6) Do you feel the material used and procedures followed in the PI unit were adequate to achieve the stated objectives?

Yes 5 4 3 2 1 No

As has been stated, there was a need to verify that both the PI and TI were taught with equal instructional quality in order to give the study validity.

Limitations of the Study

This study was confined to Central Piedmont Community College and, due to the experimental controls, is estimated to have high internal validity in the area of general chemistry. The degree to which the study has external validity depends upon several factors. External validity should be high for the general college chemistry student in the large urban type community college with age and socio-economic levels similar to those at Central Piedmont Community College. The results of the study might have less validity when applied to the traditional four year college or university, such as the University of North Carolina at Charlotte.

The extent to which the study is valid in non-chemistry courses would depend upon the degree of similarity to the study of chemistry. It probably would have validity in the physical sciences, math, and engineering at Central Piedmont Community College and at similar community colleges. External validity would probably be much lower in the non-sciences, such as sociology, history, and economics at Central Piedmont Community College.

This study was limited to representative units in general college chemistry, and it did not include other, more specialized areas of chemistry, such as biochemistry, organic, analytical, and physical chemistry. Although "chemistry is chemistry", it would be unwise to assume that what is true in the methods of teaching and learning general chemistry would also fully apply to more specialized areas of chemistry. The difference in the maturity and motivation of students and the complexity of the subject would make this an unsure assumption.

This study was limited to the Central Piedmont Community College general chemistry student who possesses some of the following characteristics:

1. The student is older than the typical four year college student, has more responsibility, and may have more financial and personal problems.
2. In many cases this student is more highly motivated and has had related experiences which make his learning more meaningful. (The literature review has shown older students to be more highly motivated.)
3. Like the general student population of Central Piedmont Community College, this student has some of the characteristics of the adult learner described by Knowles (1970). That is, he is self-directing with a vast reservoir of knowledge for learning; he is interested in learning for immediate application rather than future application.
4. In many cases, the Central Piedmont Community College chemistry student requires developmental study to be successful in the course (shown by the lower average Toledo Placement Test scores).

Significance of the Study

It is expected that this study answered some of the questions concerning the effectiveness and desirability of programmed instruction at Central Piedmont Community College, particularly in the field of chemistry. As previously mentioned, numerous comparative achievement studies between TI and PI have been made, but no highly objective studies have been done at Central Piedmont Community College in chemistry or in any other area.

Some instructors at Central Piedmont Community College have been concerned with the question of student achievement levels and preferences for the two methods. They express the opinion that students and instructors have been and still are being forced to use programmed individualized instruction with which the students "learn less" and which they "do not prefer". There may be some justification for this feeling in that no thorough study has been carried out at Central Piedmont Community College to answer these criticisms. In the first place, such a commitment to one method of instruction should be preceded by valid data. In the second place, if the method of instruction is not tested at the specific institution before being adopted as "the way", then it should at least be evaluated through a highly scientific study after it has been adopted. It is hoped, therefore, that this study will serve as a reliable reference for future questions of achievement and student preference for programmed and/or traditional instruction at Central Piedmont Community College, especially in the area of chemistry.

The study revealed the relationship between achievement by PI and TI and reading ability.

The results of the study should be of interest to the chemistry educator in both the high school and the four year college. Many of the topics covered in the study and the problem solving skills used in the study are common to both the chemistry taught in the high school and in the four year college.

Chapter 5

SUMMARY OF FINDINGS

The results of the study are presented in terms of the four hypotheses proposed in Chapter III.

Hypothesis I

This hypothesis states that Central Piedmont Community College general chemistry students of equal ability will have greater achievement when taught by partially adaptive PI than when taught by partially adaptive TI.

Table 22 shows a summary of the average gain scores obtained for each method of instruction on each of the units covered during the study. Gain scores were obtained by subtracting the raw pre-test score from the raw post-test score for each student on each unit. The average gain scores were computed for each method for each unit. The average gain score for PI was greater than the average gain score for TI on six of the eight units. TI gain scores were greater than PI gain scores on two units, as shown in Table 14. The overall average gain score for the unit is greater for PI than for TI.

Table 22

AVERAGE UNIT GAIN SCORES FOR EACH METHOD OF INSTRUCTION

Units	Methods	
	PI	TI
Exponential Numbers used in Chemistry	5.57	7.00
Significant Figures	6.67	5.38
Stoichiometry	8.45	7.34
Molar Volume Experiment	7.78	6.36
Equivalent Weight Experiment	7.97	7.26
Normality Calculations	5.12	5.42
Molarity Calculations	5.66	4.70
Redox	11.79	9.56
Overall Average	7.38	6.63

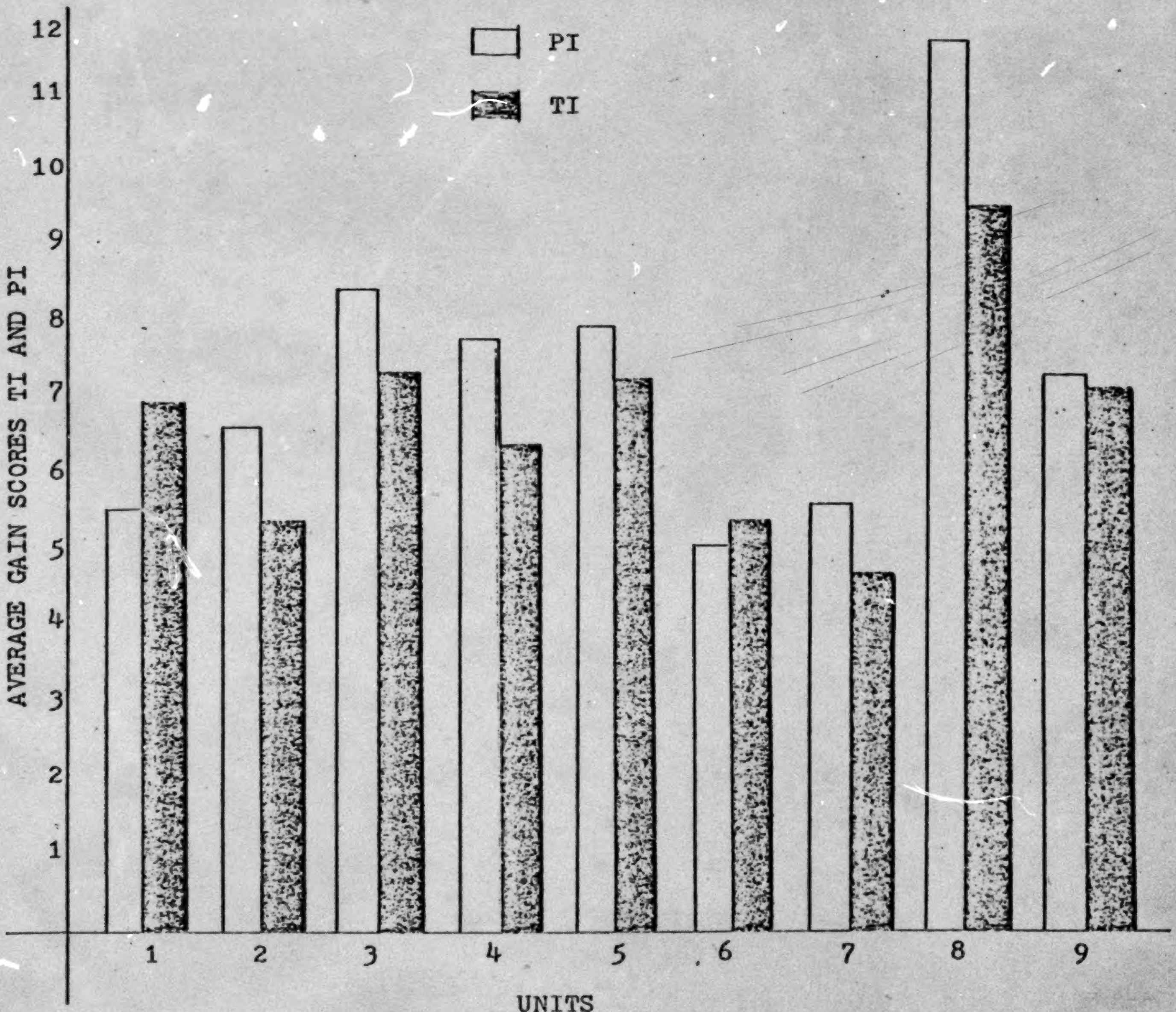
Graph B compares the average gain scores for each of the units covered in the study. Again, the graph illustrates that gain scores on PI were greater on six of the eight units covered. The graph also indicates that a substantial amount of learning took place in both the TI group and the PI group. The maximum gain score possible was 16.

The t-test was used to analyze the gain scores for each of the units. The results are summarized in Table 23.

Although the gain scores for the PI treatment were greater than those for TI treatment on six of the eight units, the results of the t-test do not support hypothesis I. The

Graph B

AVERAGE UNIT GAIN SCORES FOR EACH METHOD OF INSTRUCTION



1. Exponential Numbers in Chemistry
2. Significant Figures in Chemistry
3. Stoichiometry
4. Molar Volume Experiment
5. Equivalent Weight Experiment
6. Normality
7. Molarity
8. Redox
9. Overall Average

Table 23

CALCULATED T-VALUES FROM THE GAIN SCORES

Unit	Critical t-value $p < 0.10$ Two Tailed Test	Critical t-value $p < 0.01$ Two Tailed Test	t-value	df
Exponential Numbers in Chemistry	1.67	2.66	1.13	86
Significant Figures	1.67	2.66	1.79	89
Stoichiometry	1.67	2.66	1.53	76
Molar Volume Experiment	1.67	2.66	1.78	68
Equivalent Weight Experiment	1.67	2.66	0.75	67
Normality	1.67	2.66	0.34	62
Molarity	1.67	2.66	1.13	60
Redox	1.67	2.66	1.61	60

(Tuckman, p. 370)

hypothesis is not supported on any of the units in the study at either $p < 0.01$ or $p < 0.05$ level for a two tailed test. The results of the t-test supports the null hypothesis--there is no significant difference in achievement between the two methods of instruction. Although the null hypothesis is supported at the 0.01 level, it should be noted that in two units, significant figures and molar volume there is a significant difference in the gain scores at the 0.10 level. It should also be noted that in two other units the t-test value approaches significance at the 0.10 level.

The two groups used in the study appeared to be equal in overall achievement. Neither group consistently scored higher on units taught by one particular method of instruction (TI or PI). The overall average gain score in both TI and PI units for Group A was 7.06. The overall average gain score in both TI and PI units for Group B was 6.95. This is further indication that Groups A and B were equal in learning ability and that any difference in achievement was due to the method of instruction and not to inherent differences in the groups. A comparison of the groups' overall achievement is shown in Table 24.

Table 24
OVERALL ACHIEVEMENT - GROUPS A AND B

	PI Average Gain Score	TI Average Gain Score	Average Overall Gain Scores
Group A	7.43	6.68	7.06
Group B	7.32	6.58	6.95

The results of the Toledo Placement Test reveal that the subjects were below average in their previous achievement and/or aptitude in chemistry. The reported cut-off score used on the Toledo Placement Test (TCPC) at Toledo University, Ohio was 40 (Hovey, Kroln, 1963). Those students at the University of Toledo who scored below 40 on the test were advised to take a developmental course in chemistry before taking the regular college chemistry course.

The cut-off score reportedly used at Cuyahoga Community College, Cleveland, Ohio was 45 (Laughlin, 1976). The mean TCPC scores for the A and B Groups in this study were 32.2 and 34.3, respectively. The median score for both the A and B group was 33. It was also found that only 23% of the students in the study had TCPE scores of 40 or greater. Based on this test instrument, the majority of subjects were below average in preparation for college chemistry. If this group were taking the course at the previously mentioned schools, about 80% would be advised to complete a remedial chemistry course before the regular college chemistry. However, these scores are only slightly lower than the TCPC scores of previous CPCC chemistry students treated in another study. The mean score for CPCC students was found to be 36 with a median of 34 (Cheek, 1972). The similarity of TCPE scores suggest that the groups used in this study is typical of the CPCC general chemistry student.

Again, the results do not support the hypothesis but support the null hypothesis--there is no significant difference in achievement by PI and TI in chemistry at CPCC.

The outcomes of the pilot study support the results of the MARP. There was no significant difference in the mean gain scores for the two methods of instruction.

Hypothesis II

This hypothesis states that Central Piedmont Community College general chemistry students will prefer to be taught by partially adaptive TI rather than partially adaptive PI.

One method of testing this hypothesis was the chi-square analysis. This analysis was run on the sums of the A - E cells in Part II of the questionnaire. For each module, the students rated certain aspects of each method parts 7-16 and parts 17-26.* These were tabled for each column for each method and a 2 x 5 chi-square analysis was run on each module. The results are summarized in Table 25.

---

*

A.	TRADITIONAL METHOD	A B C D E	
7.	Worthless		Valuable
8.	Difficult		Easy
9.	Not Involved		Involved
10.	Unimportant		Important
11.	Dull		Interesting
12.	Useless		Useful
13.	Monotonous (Boring)		Varied
14.	Impersonal		Personal
15.	Unfair		Fair
16.	Ordinary		Far Out

B.	PI METHOD	A B C D E	
17.	Worthless		Valuable
18.	Difficult		Easy
19.	Not Involved		Involved
20.	Unimportant		Important
21.	Dull		Interesting
22.	Useless		Useful
23.	Monotonous (Boring)		Varied
24.	Impersonal		Personal
25.	Unfair		Fair
26.	Ordinary		Far Out

Table 25

CHI-SQUARE ANALYSIS OF METHOD DESIRABILITY

Module	A	B	C	D	E	Computed χ^2 Value	Critical Value χ^2 at $p < 0.01$
Significant Figures							
TI	32	175	242	314	198	6.65	13.27
PI	36	70	152	292	237		
Stoichiometry							
TI	16	44	178	104	53	14.40	13.27
PI	22	40	117	113	68		
Molar Volume and Equivalent Weight							
TI	12	37	186	104	56	10.13	13.27
PI	15	33	104	50	26		
Module Normality and Molarity							
TI	6	3	220	174	69	5.23	13.27
PI	8	37	182	117	58		
Redox							
TI	19	55	169	155	66	2.35	13.27
PI	19	41	163	122	55		

The results of the chi-square analysis do not support the directional hypothesis on four of the modules. The null hypothesis is supported on four of the five modules--that is there was no significant difference in student attitude toward the two methods. The chi-square value for the stoichiometry module is greater than the critical value indicating there was a significant difference in the rating of the two methods on the module. It should be noted that the module on molar volume and equivalent weight has a chi-square value that approaches significance at the $p< 0.10$ level.

Based on this part of the study, it appears that there was some significant difference in how students feel about the two methods of instruction.

The results of the most important question in the questionnaire, number 31 located in Part IV of the questionnaire, support the opposite of the hypothesis. The question reads: "Based on their presentation, which method of instruction would you prefer to be used on you?" A summary of the results are shown in Table 26. The students indicate a strong preference for PI in four of the five modules in a ratio of about 3:2 (PI:TI). In other words about 60% of the students preferred PI and about 40% of the students preferred TI.

Table 26

STUDENT PREFERENCE OF PI, TI

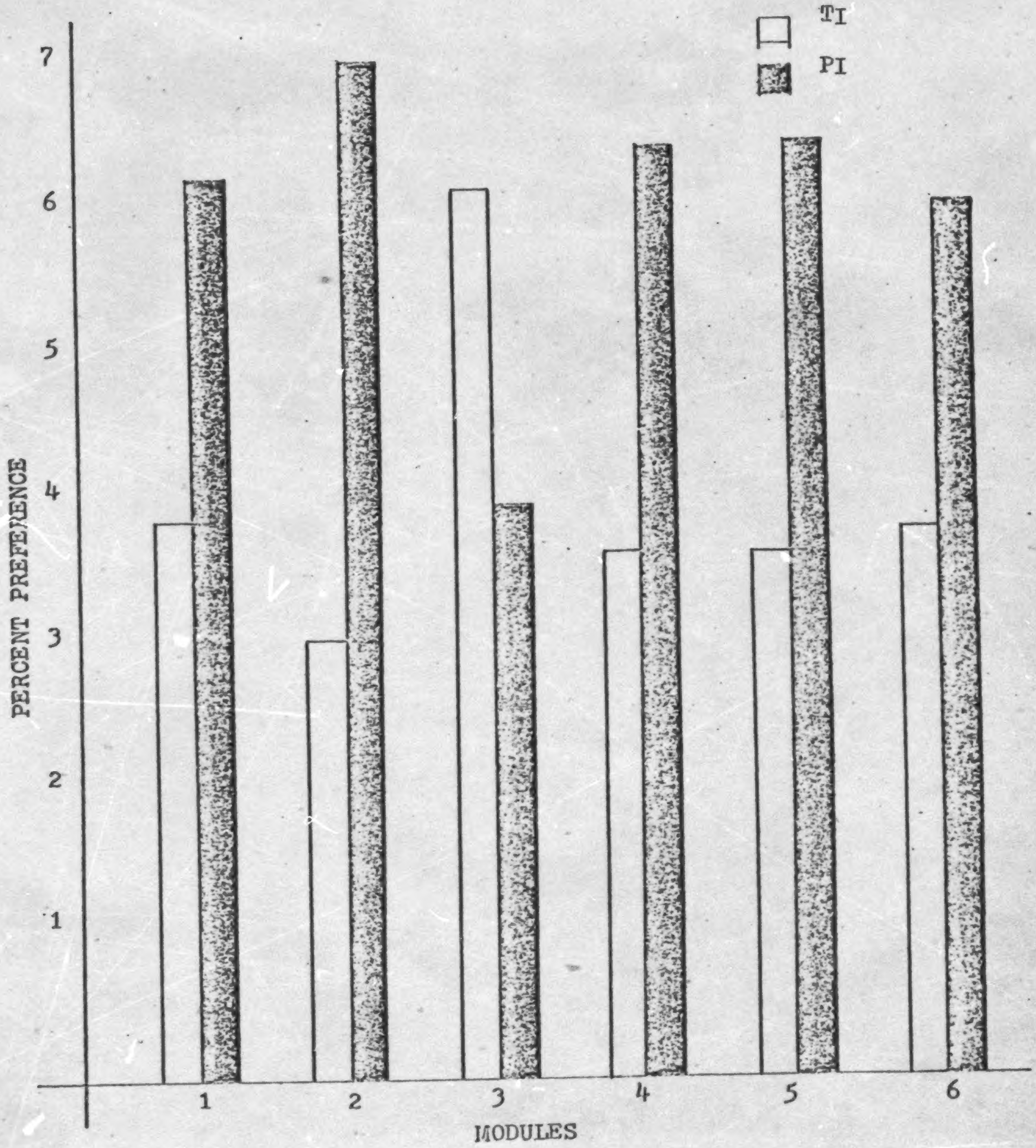
		Percent TI	Percent PI	Percent Some of Both
Module 1	Significant figure and Exponential Numbers in Chemistry	38	62	40
Module 2	Stoichiometry	30	70	30
Module 3	Molar Volume and Equivalent Weight Experiments	61	39	46
Module 4	Normality and Molarity	36	64	44
Module 5	Redox	36	64	44
	Average	40	60	40

It should be noted at this point that student responses to question 31 of the questionnaire reveals that they prefer PI to TI in the stoichiometry module in which the previously mentioned chi-square test showed a significant difference.

Graph B compares student preference for PI and TI in each of the modules and depicts the overall average for all the modules. This graph reveals a clear-cut preference for PI by chemistry students at CPCC.

Graph C

STUDENT PREFERENCE OF PI OR TI

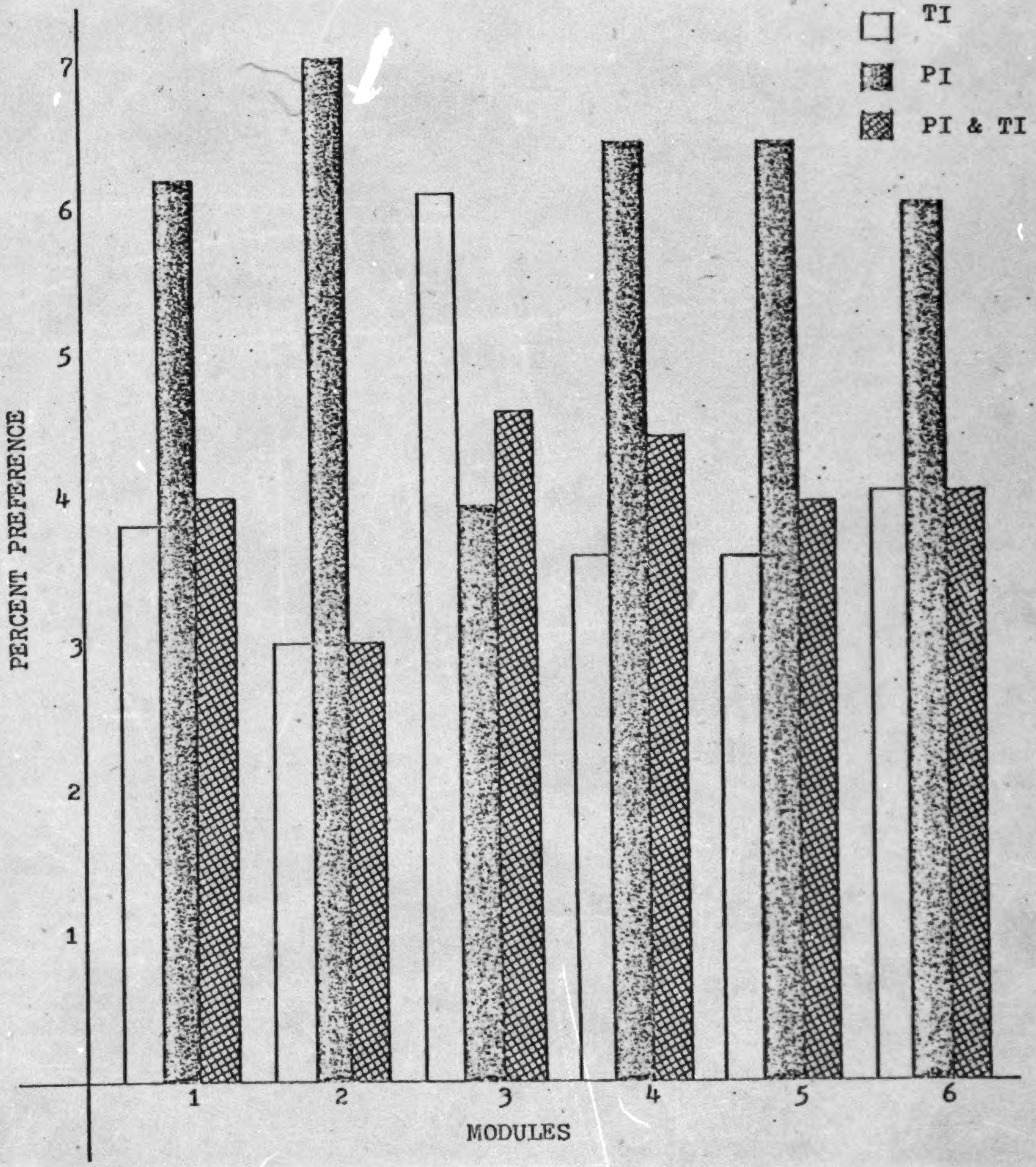


1. Significant Figure and Exponential Numbers
2. Stoichiometry
3. Molar Volume and Equivalent Weight
4. Normality and Molarity
5. Redox
6. Overall Average

It is interesting to note that the only module in which the students preferred TI to PI was the molar volume equivalent weight which consisted of lab experiment in a closed lab situation. Another observation was that many students preferred to have both methods used in the instructional program. This is illustrated in Graph D.

Graph D

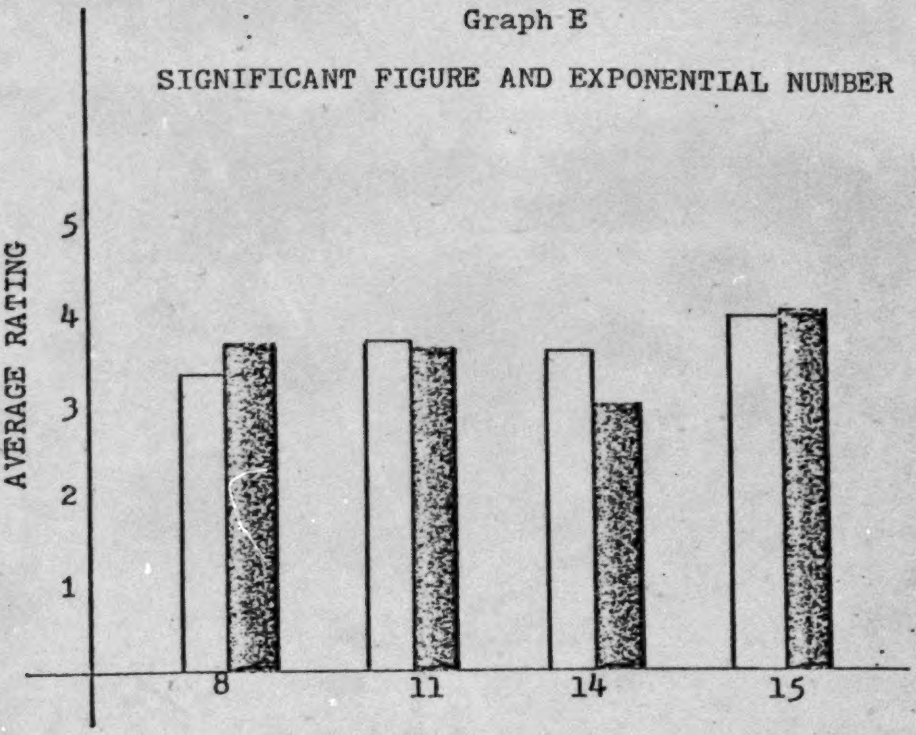
STUDENT PREFERENCE OF TI, PI AND BOTH



1. Significant Figures and Exponential Numbers
2. Stoichiometry
3. Molar Volume and Equivalent Weight
4. Normality and Molarity
5. Redox
6. Overall Average

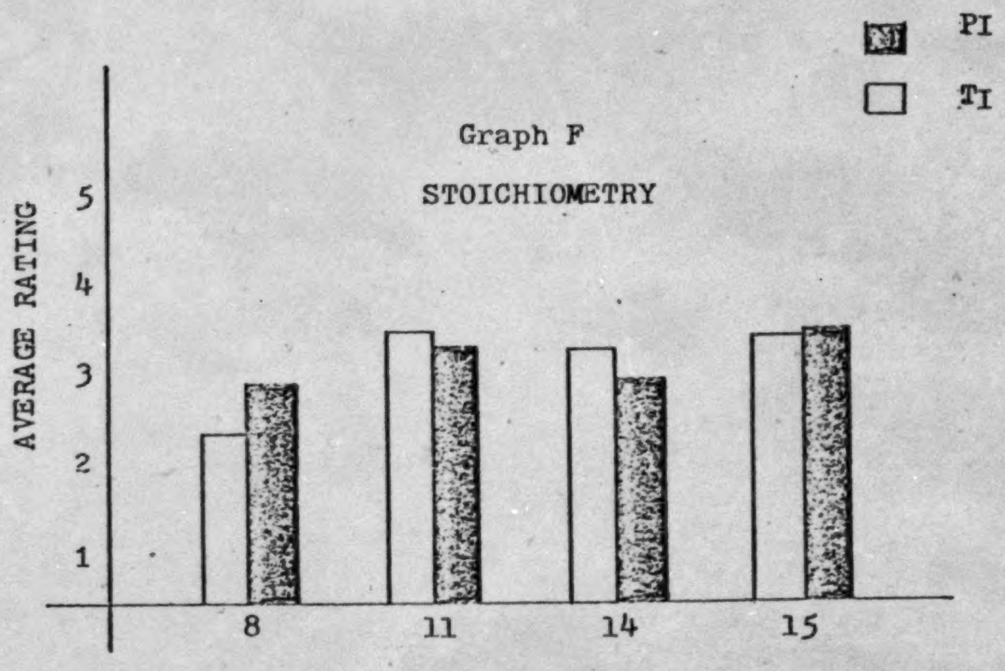
In summary, the data strongly supports the opposite of the hypothesis--that is CPCC general chemistry students prefer to be taught by PI rather than TI. The results of the pilot study do not support the MARP results. As was shown, students preferred TI to PI in the pilot study in which the time used for PI and TI were exactly the same.

To compare some of the key characteristics of the two methods of instruction, graphs were constructed for each of the modules using data from Part II of the questionnaire. A rating scale of 1-5 was assigned to the A, B, C, D, E columns (from left to right 1-5) and numerical averages were computed for four of the more important characteristics in the teaching of chemistry. They were difficult-easy, dull-interesting, impersonal-personal, and unfair-fair. One common complaint of TI in chemistry has been that it is too difficult and sometimes unfair. A common complaint of PI used in chemistry has been that it is dull and impersonal. This data is plotted in the following graphs E - J.



Graph E

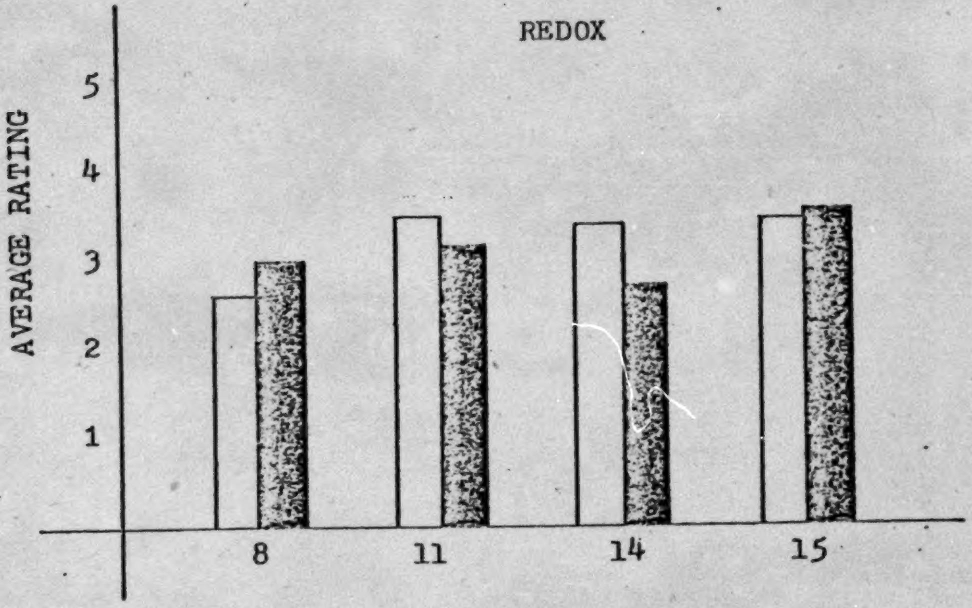
SIGNIFICANT FIGURE AND EXPONENTIAL NUMBER



Graph F

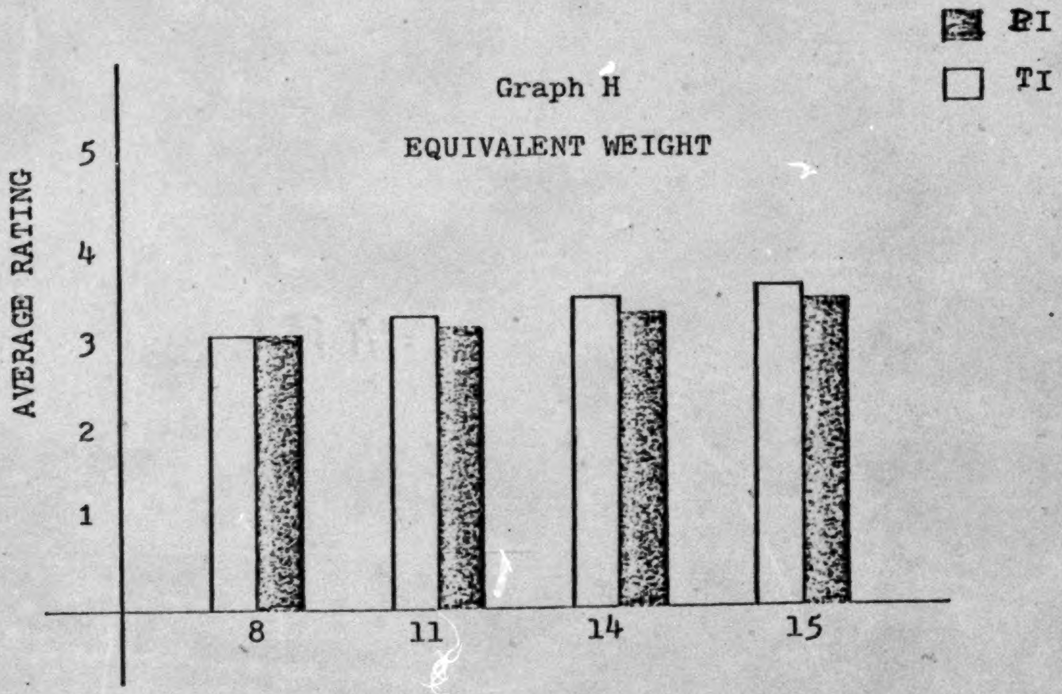
STOICHIOMETRY

8. Difficult - Easy
11. Dull - Interesting
14. Impersonal - Personal
15. Unfair - Fair



Graph G

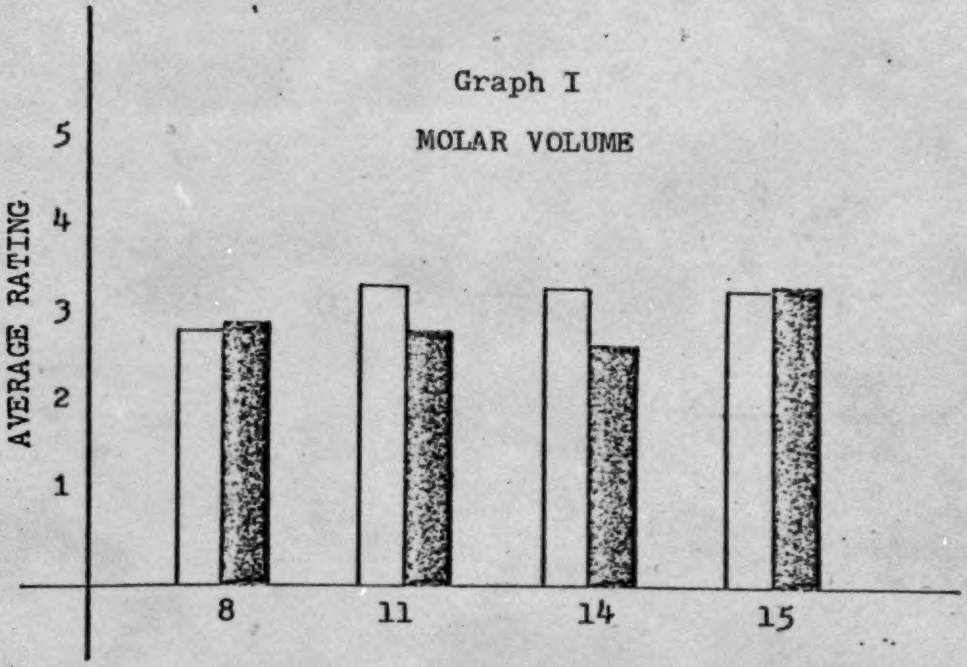
REDOX



Graph H

EQUIVALENT WEIGHT

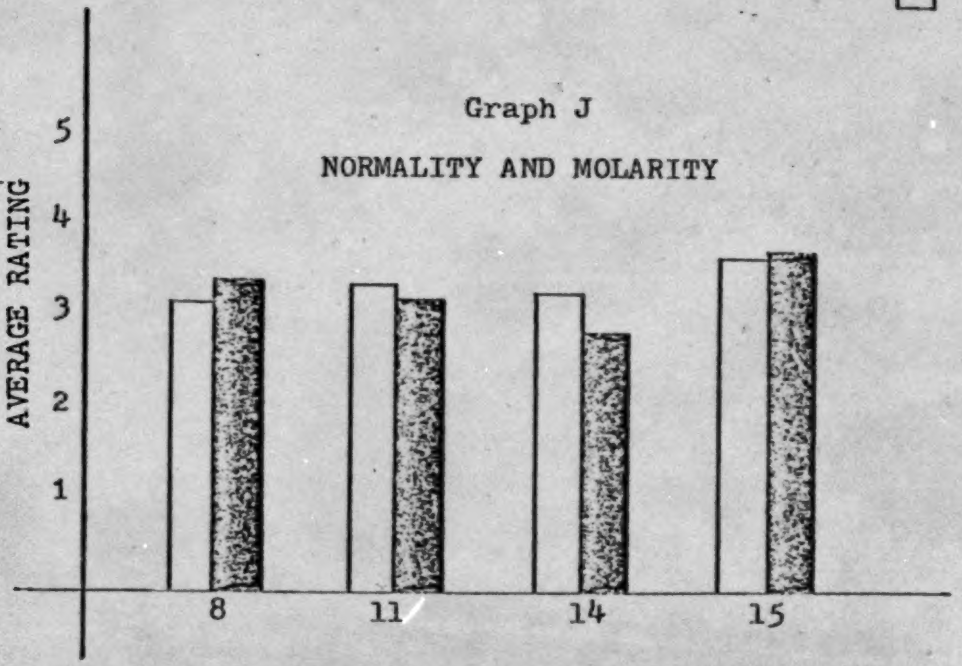
8. Difficult - Easy
11. Dull - Interesting
14. Impersonal - Personal
15. Unfair - Fair



Graph I

MOLAR VOLUME

▨ P.I
☐ TI



Graph J

NORMALITY AND MOLARITY

8. Difficult - Easy
11. Dull - Interesting
14. Impersonal - Personal
15. Unfair - Fair

The differences in the rating for these forms are not large in most cases. Even so it appears that programmed instruction is considered to be easier and fairer while traditional instruction is more personal and interesting. These results support the feelings of the investigator based on experience with the two methods of instruction.

Hypothesis III

This hypothesis states that Central Piedmont Community College general chemistry students of lower reading ability will achieve more when taught by partially adaptive PI than by partially adaptive TI.

The results of the study do not support the hypothesis but support the null hypothesis--that there is no significant difference in achievement when low reading ability students were taught by PI or TI.

The results of the t-test are shown in Table 27.

Table 27

MEAN GAIN SCORES BY METHOD - LOW READING GROUP

Method	Total Average Gain Scores - All Units	df	t-value
PI	5.75	54	0.63
TI	6.32		

$t=0.63$ is not significant at $p<0.01$.

As shown in Table 27, the average gain score for the low reading group is slightly higher on TI than on PI but the difference is not significant, even at the 0.05 level.

Hypothesis IV

Hypothesis IV states that Central Piedmont Community College chemistry students of higher reading ability will achieve more when taught by partially adaptive TI than by partially adaptive PI.

Again, the results do not support the hypothesis. When the total average mean gain scores for each method are treated using the t-test, there is no significant difference in achievement. Therefore, the null hypothesis is supported. These results are summarized in Table 28.

Table 28

MEAN GAIN SCORES BY METHOD - HIGH READING GROUP

Method	Total Average Gain Score - All Units	df	t-value
PI	7.08	46	0.82
TI	6.88		

t = 0.82 is not significant at $p < 0.01$

The average gain score for the high reading group is higher on PI than on TI. However, as shown, this is not statically significant.

As previously mentioned, the Nelson Denny Reading Test was used to determine the high and low reading groups. All students who had reading scores above the median score of 52 percentile on the Nelson Denny Reading Test (Form C) was placed in the high reading group. All students who had reading scores below the median score of 52 percentile for the test group were placed in the low reading group. Both the median score and the mean score of 53 indicate the group had a reading ability equal to an average college freshman student. The norm used for this group was that given for the thirteenth year.

Hypothesis V

This hypothesis states that there will be no significant difference in the quality of instruction presented in the TI units and the PI units based on the rating scale in the questionnaire.

To insure that both TI and PI were presented in a quality fashion, student ratings for questions 1 and 2; 3 and 4; and 5 and 6 of Part I of the student evaluation form were summarized. Three 2 x 5 chi-square analyses were run on each of the modules. The data and results are presented in Table 29.

Table 29

QUALITY OF INSTRUCTION FOR TI AND PI

	Chi-square Value for Each Module				
	1	2	3	4	5
Clarity of Objectives	1.0	1.2	2.2	3.4	3.1
Feeling of Accomplishment of Objectives	6	0.7	1.0	2.7	5.9
Evaluation of Procedures	2.1	1.3	1.9	1.1	4.9

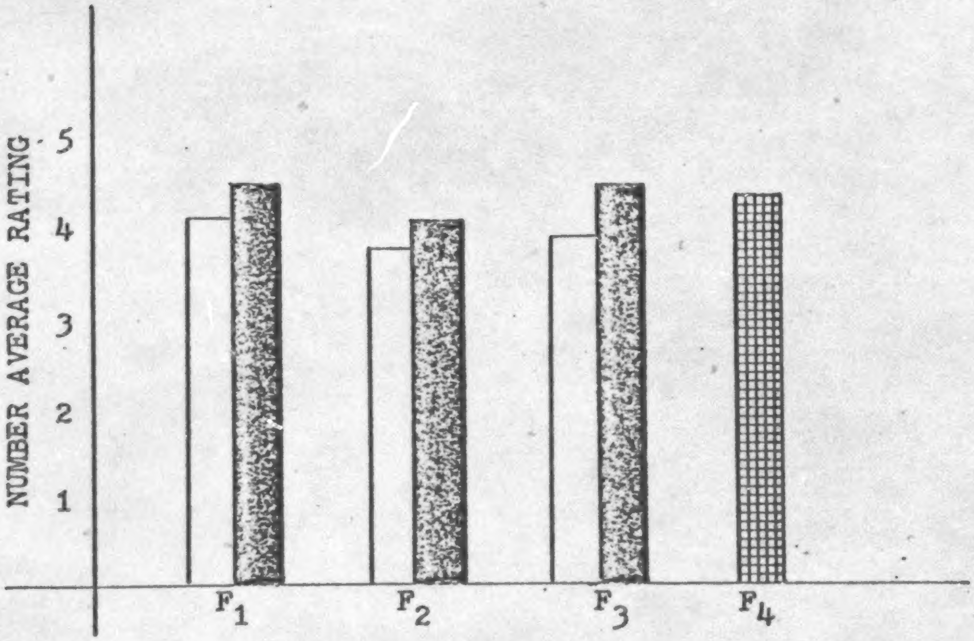
Critical χ^2 Value is 13.27 at the 0.01 level. 13.27 computed χ^2

The results indicate that the quality of TI was not significantly different from PI. None of the calculated chi-square (χ^2) values are close to the critical(χ^2) values. The results strongly support the null hypothesis--there is no significant difference in the quality of instruction presented in TI and PI. Thus, any difference in achievement by the subjects in the study was due to difference in instructional methods and not the quality of instruction.

To illustrate that there was little difference in the quality of instruction on the two methods, graphs were constructed from the numerical average rating for "clarity of objectives," "feeling of accomplishment of objectives" and "evaluations of procedure used." These were determined for each of the modules and are presented in Graphs K - P.

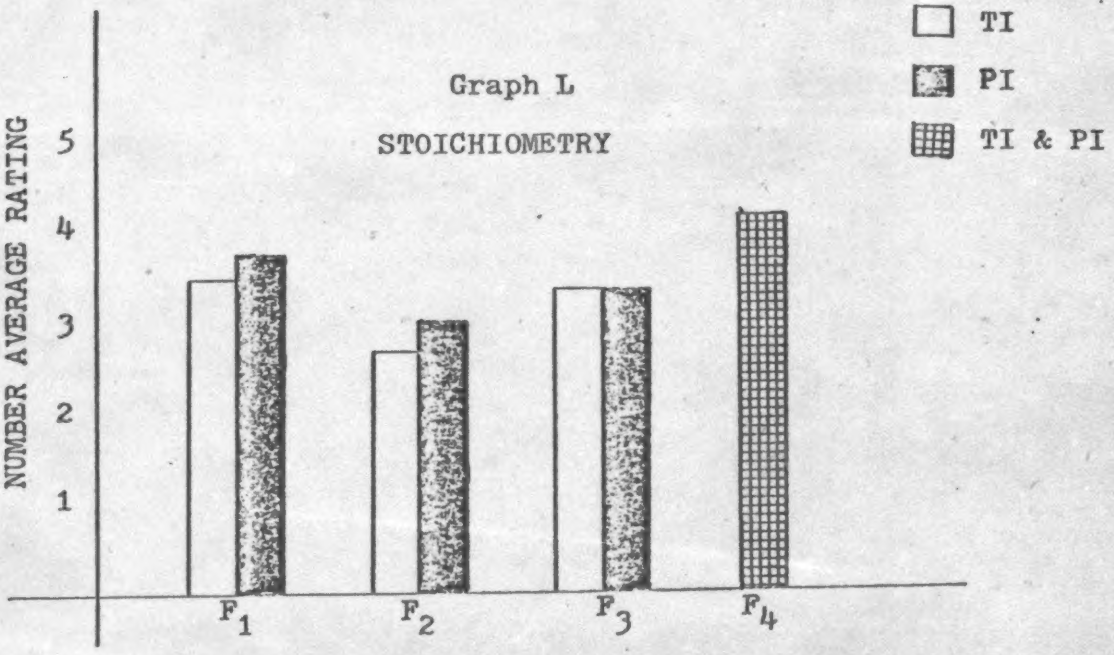
Graph K

SIGNIFICANT FIGURES AND EXPONENTIAL NUMBERS



Graph L

STOICHIOMETRY

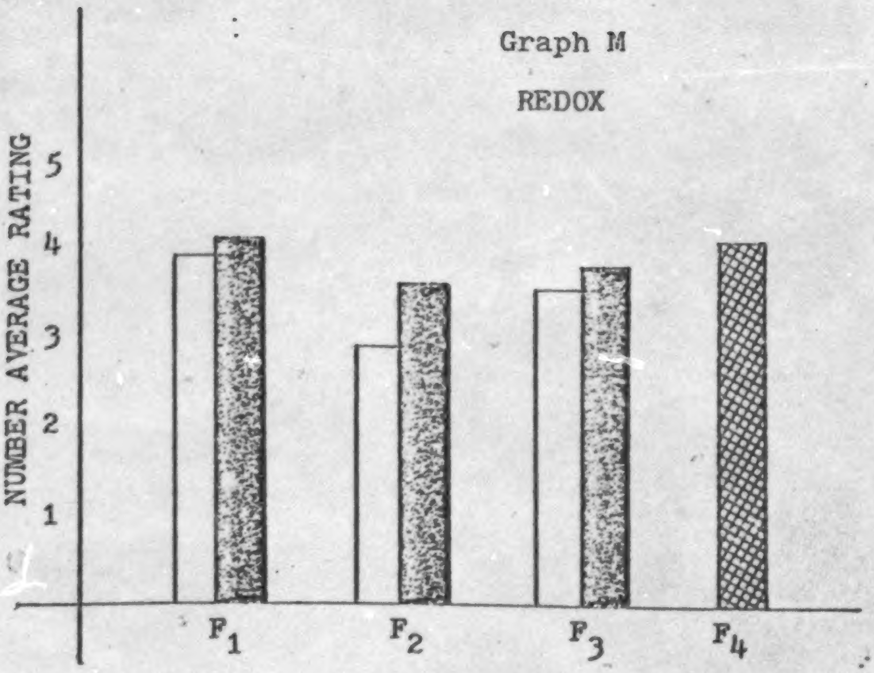


F_1 Were the objectives clear for the unit taught by TI?
Were the objectives clear for the unit taught by PI?

F_2 Are you satisfied that you accomplished the objectives in the TI unit?
Are you satisfied that you accomplished the objectives in the PI unit?

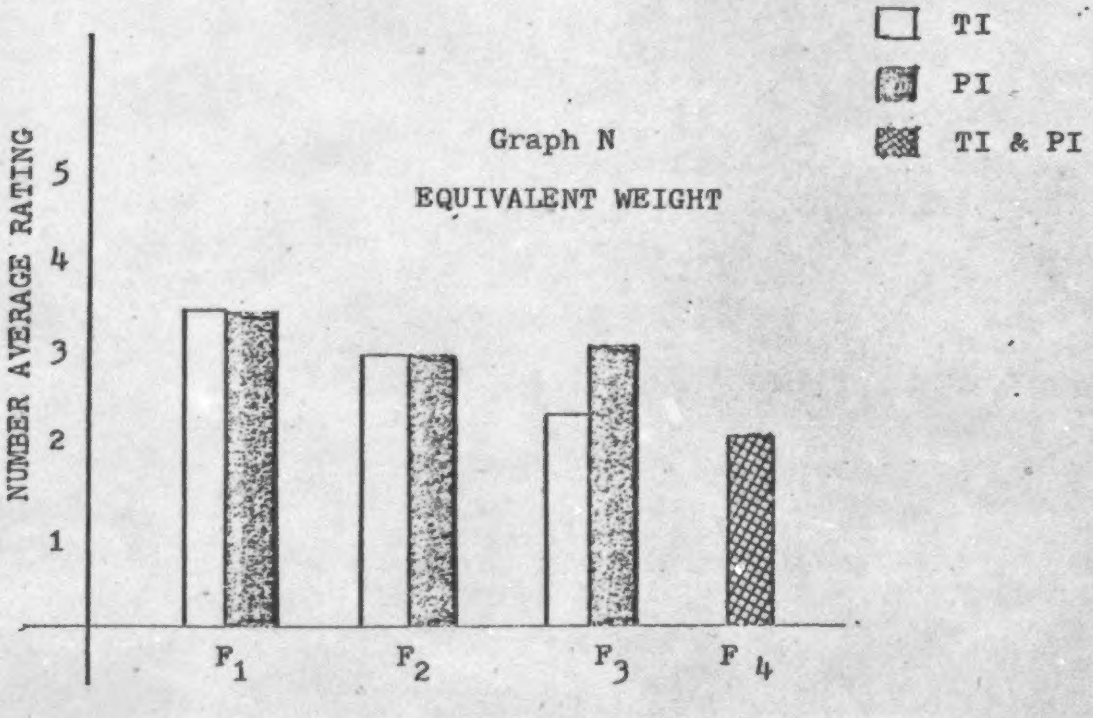
F_3 Do you feel the materials used and procedures followed in the TI unit were adequate to achieve the stated objectives?
Do you feel the materials used and procedures followed in the PI unit were adequate to achieve the stated objectives?

F_4 Do you feel the objectives were adequately covered in the post-test?



Graph M

REDOX



Graph N

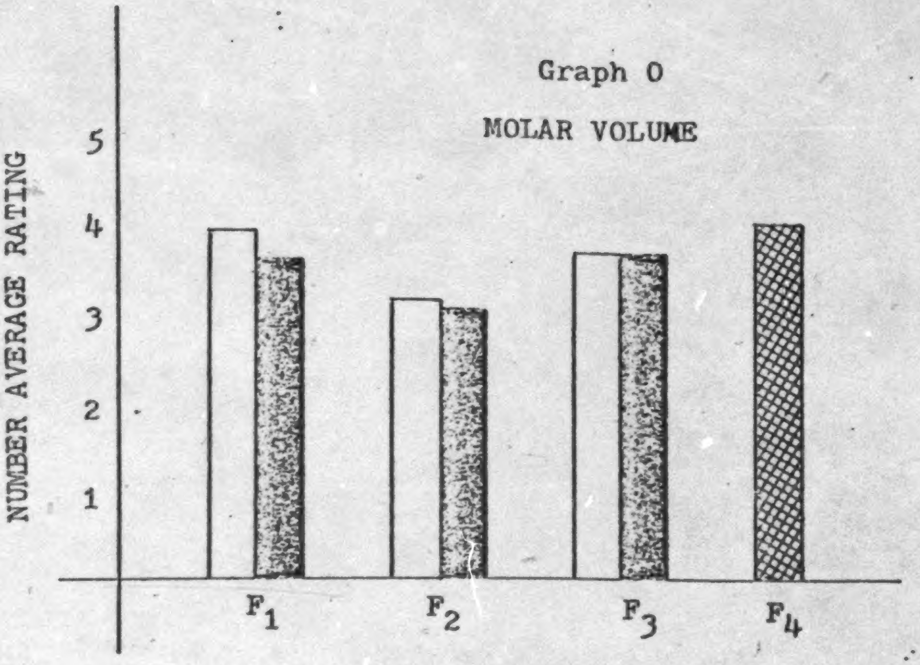
EQUIVALENT WEIGHT

F_1 Were the objectives clear for the unit taught by TI?
Were the objectives clear for the unit taught by PI?

F_2 Are you satisfied that you accomplished the objectives in the TI unit?
Are you satisfied that you accomplished the objectives in the PI unit?

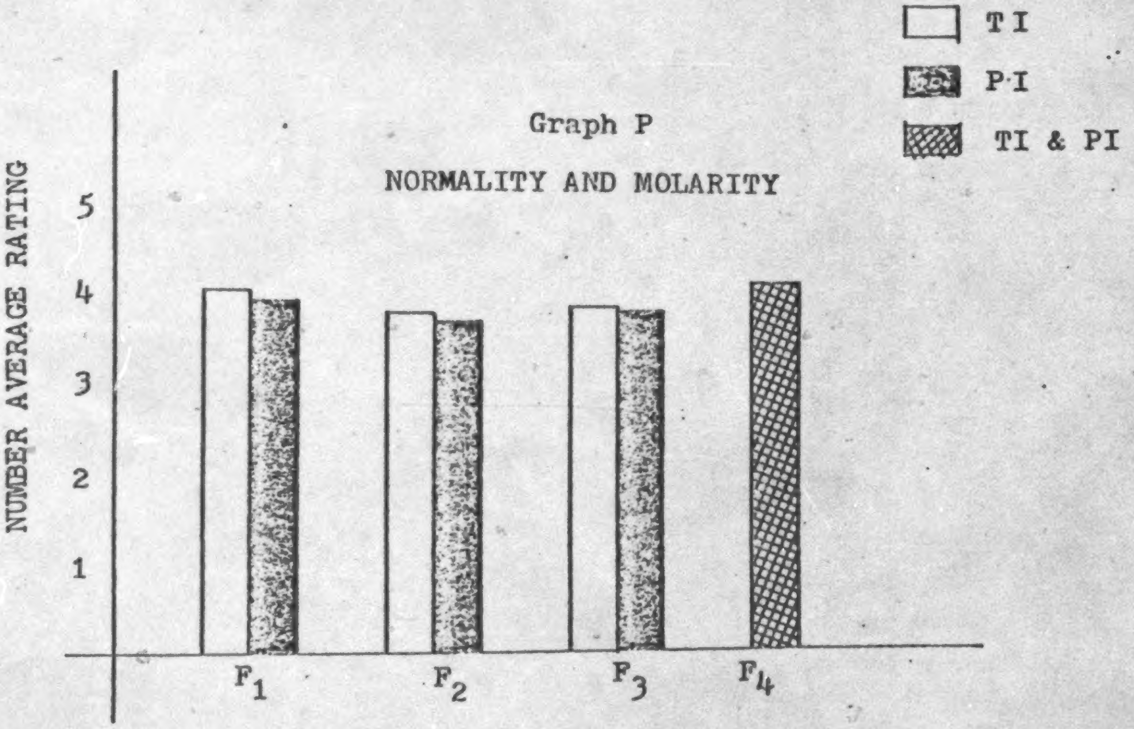
F_3 Do you feel the materials used and procedures followed in the TI unit were adequate to achieve the stated objectives?
Do you feel the materials used and procedures followed in the PI unit were adequate to achieve the stated objectives?

F_4 Do you feel the objectives were adequately covered in the post-test?



Graph O

MOLAR VOLUME



Graph P

NORMALITY AND MOLARITY

F_1 Were the objectives clear for the unit taught by TI?
Were the objectives clear for the unit taught by PI?

F_2 Are you satisfied that you accomplished the objectives in the TI unit?
Are you satisfied that you accomplished the objectives in the PI unit?

F_3 Do you feel the materials used and procedures followed in the TI unit were adequate to achieve the stated objectives?
Do you feel the materials used and procedures followed in the PI unit were adequate to achieve the stated objectives?

F_4 Do you feel the objectives were adequately covered in the post-test?

These graphs indicate little difference in the ratings with PI having a slightly higher overall rating than TI. It is interesting to note that TI averages are higher on the modular involving lab experiments.

What students liked and disliked about each method of instruction are summarized in Table 30. This data was taken from the student evaluation questionnaire and which asked:

27. "What did you like most about the traditional class unit?"
28. "What did you like least about the traditional unit?"
29. "What did you like most about the PI unit?"
30. "What did you like least about the PI unit?"

These questions were subjective and all students did not respond although many comments were written. As in the pilot study, most responding students gave similar reactions to the questions. The frequency of student comments are summarized for each method on each module in Table 30 in terms of what they liked and disliked about the methods.

Table 30

WHAT STUDENTS LIKED MOST AND LEAST ABOUT EACH METHOD OF INSTRUCTION

TI

Liked

A. "Able to ask questions."

Module	1	2	3	4	5
Frequency of Comment	23	22	16	16	16

B. "Personal Contact with Instructor."

Module	1	2	3	4	5
Frequency of Comment	5	4	4	6	4

C. "Explanation Given."

Module	1	2	3	4	5
Frequency of Comment	1	6	7	8	4

Disliked

A. "Lack of Time to Complete."

Module	1	2	3	4	5
Frequency of Comment	15	12	10	7	7

B. "Required more concentration, missed a few parts--difficult."

Module	1	2	3	4	5
Frequency of Comment	12	10	8	4	5

PI

Liked

A. "Self-paced."

Module	1	2	3	4	5
Frequency of Comment	25	19	16	16	14

B. "Convenient."

Module	1	2	3	4	5
Frequency of Comment	5	8	4	6	4

Table 30
(Continued)

C. "Repetitious."

Module	1	2	3	4	5
Frequency of Comment	3	4	6	2	1

Disliked

A. "Unable to Ask Questions."

Module	1	2	3	4	5
Frequency of Comment	14	15	13	12	10

B. "Time Consuming."

Module	1	2	3	4	5
Frequency of Comment	12	11	12	11	9

C. "Impersonal."

Module	1	2	3	4	5
Frequency of Comment	10	7	6	4	5

As mentioned in the procedures section of Chapter 4, an attempt was made to determine the amount of study time used by students in TI and in PI. The average total time spent by students on TI was larger than by PI on five of the eight units covered. The validity of these results are questionable because only about 50% of the students reported their time.

After completing the main portion of the study, it was decided to determine if there were any relationship between either high or low scores on the TCPE and achievement in TI and PI. The data needed for these determinations had already been collected and the application of the results in the future planning of chemistry programs at CPCC was obvious.

The total group was divided into the high-score TCPE and the low-score TCPE group as shown in Table 31. The mean TCPE score for the low group was 24 while the mean TCPE score for the high group was 41.

Table 31

AVERAGE TCPE SCORES FOR HIGH AND LOW GROUPS

Low Group	24
High Group	41

The gain scores were determined for the high score and the low score TCPE groups. The t-test was run to determine if the difference in gain scores was significant.

As may be observed in Table 32, there was no significant difference between achievement by TI and PI for students with high TCPE scores. Also there was no significant difference between achievement by TI and PI for students with low TCPE scores. The null hypothesis is supported in both cases.

Table 32

LOW AND HIGH TCPE SCORES AND ACHIEVEMENT

			PI	TI
High-score TCPE			7.32	7.13
	df	76		
	t-value	1.09		
Low-score TCPE			6.20	6.24
	df	74		
	t-value	0.89		

Chapter 6

CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

Conclusions

The findings in this study led to the conclusions that:

1. CPCC students of general chemistry achieve as much by one method of instruction as by the other method. Achievement appears to be somewhat independent of the method of instruction when other variables are held constant.
2. CPCC students of general chemistry appear to have a preference for programmed instruction when used in conjunction with a regular chemistry class being supervised by the classroom instructor.
3. CPCC general chemistry students appear to have a preference for traditional instruction in the lab portion of the general chemistry course when taught by the classroom instructor in a closed lab.
4. CPCC general chemistry students of high reading ability achieve as much by one method of instruction as the other.
5. CPCC general chemistry students of low reading ability achieve as much by one method of instruction as the other.

6. There was no significant difference in the quality of instruction presented in the two methods of instructions in the study.

Discussion

The findings in this study seem to support many other comparative studies in that achievement was found to be somewhat independent of the method of instruction. It should be noted, however, that in six of the eight units, achievement by PI was higher. Although this difference in achievement was not significant at the 0.01 level, achievement by PI was significantly greater than TI on two of the units at the 0.10 level. In two other units achievement differences approached significance at the 0.10 level.

As previously stated, this study was conducted in regularly scheduled chemistry classes at CPCC. The normal course procedure involves the use of learning objectives. It was felt that both PI and TI should have these objectives in order to be fair to the students. It was believed, too, that for the study to be meaningful and for it to have direction, learning objectives were necessary for both TI and PI. In addition, the experimental design required the use of a pre-test and post-test on each unit for both TI and PI. The use of objectives, pre-test and frequent post-tests had an obvious built-in advantage for TI because traditional instruction does not usually employ either objective pre-tests or frequent post-tests.

To gain acceptance of the results and conclusions of this study by the faculty and staff of CPCC and other community colleges, it was felt that students in TI units should be given every advantage possible within the limits of TI. This was another reason for the use of learning objectives in TI.

Even with these atypical built-in advantages for TI, achievement by TI was no better than by PI.

The significance of these results is that students learned just as much using programmed instruction without the presence of an instructor as when they used traditional instruction which required the presence of a classroom teacher. Evidently, the chemistry teacher does not have to be physically present when the learning of specified information takes place. It should be noted, also, that the information was on a relatively high level of sophistication. This learning without the presence of an instructor has much educational significance and implication.

This study also supports many other studies in that the majority of students preferred PI to TI in most of the units. Although the chi-square analysis of student ratings of the various characteristics of TI and PI showed no significant difference in four of the five modules, student responses to the direct questions concerning method preference indicated that they preferred PI. One set of data implies that students had a slight preference for PI while another set of data strongly indicates a student preference for PI.

It appears that much greater weight should be given to data obtained from the direct questions. Seemingly, results obtained from a direct question should be more valid than results implied from the statistical analysis of a rating scale. The purpose in the rating scale was not only to estimate the overall preference in terms of specific characteristics but to "zero in" on certain aspects of each method.

One interesting result of this part of the study was the apparent student preferences for TI in the lab module. This is cause for some concern because all of the general chemistry lab experiments at CPCC are taught by PI. As previously mentioned, one of the basic assumptions in developing the instructional material for lab was that students preferred an open PI lab. Results of this study reveal that students prefer just the opposite--that is, they preferred the closed TI lab taught by the classroom teacher. Even though the time spent on the lab module was about 30% of the total time used for the study, it was felt that this data was valid and reliable.

What is the significance of this finding? This may be attributed to well-known instructional problems encountered when a different person than the classroom instructor supervises or teaches the lab portion of a course. These problems are varied but usually involve student evaluation, assigning of lab grades, student motivation, student counseling, etc. Although the materials used in the PI lab were individualized and have proven to be completely workable in the past, some student-lab instructor contact is necessary. For example, the lab paraprofessional is required to initial the experiment at certain check points in the experiment and to grade unknowns.. A few students ask for help from the lab paraprofessional in locating and constructing chemical apparatus. Most importantly the chemistry lab is where the student's curiousity becomes aroused and many questions are asked. Numerous times these questions go unanswered by the lab supervisor. This is most likely due to a lack of time, professional experience or training to answer these questions or to direct the student to the proper source. Sometimes it may be due to a plain lack of interest on the part of the paraprofessional.

In this study, the TI closed lab was supervised by a regular classroom instructor with many years of teaching experience and professional training. Even though the materials used in the TI lab were not nearly as well organized or complete as the PI lab and even though the students had to attend Saturday classes (Chemistry classes are not usually taught on Saturday.) for the TI closed lab, they preferred the TI closed lab about three-to-two. This is significant and points to a problem that has been suspected to exist at CPCC in lab courses since the present system has been in operation--the problem of paraprofessionals teaching the lab portion of the course.

It is believed that students would have preferred the PI open lab if the classroom instructor had been supervising the PI lab during the study. The study was not designed to have the classroom teacher supervise the PI lab because:

1. The course is not normally taught with the classroom teacher supervising and teaching the lab and there was need to test the present system.
2. There was not adequate lab space to complete the study using two labs.

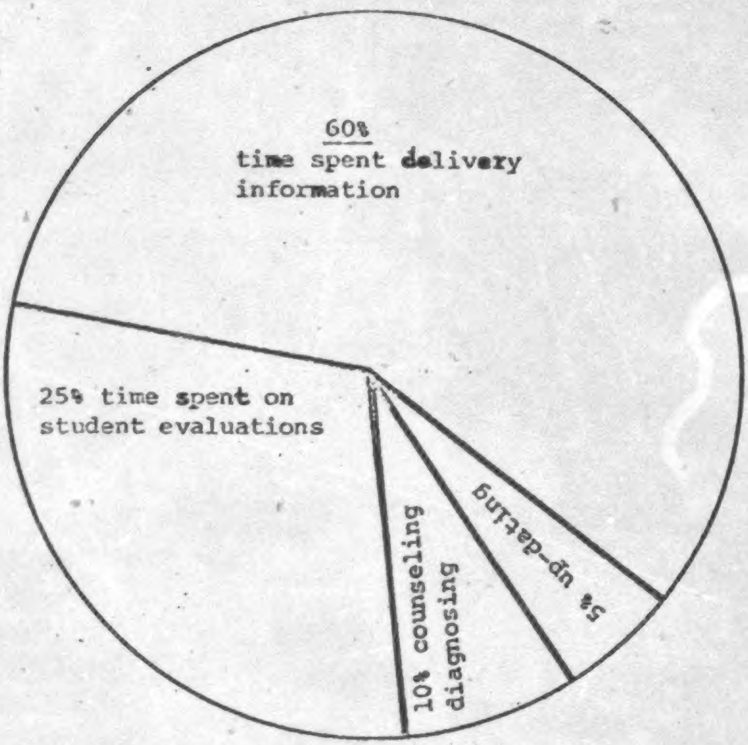
If the results of this study are valid and reliable, one can assume that students of general chemistry at CPCC prefer PI to TI when used in the manner described in the study. If students prefer PI to TI and if they achieve just as much (in many cases at a faster pace), then an obvious suggestion is to continue the use and development of programmed instruction in general chemistry at CPCC.

This is a giant step in the evaluation of educational methodology and should lead to better learning. The wider use of PI in the general chemistry course should not only fulfill the student's choice of method but it should relieve the classroom teacher from the sometimes monotonous task of teaching the same old basic principles and concepts--basic , old, but, nevertheless, important. Ideally, this instructor release time should allow for much better overall teaching. The classroom instructor would be free to advise and counsel and use more individual diagnoses in his teaching of chemistry.

The instructor should have much greater time to revise, develop, up-date and evaluate material used in the course.

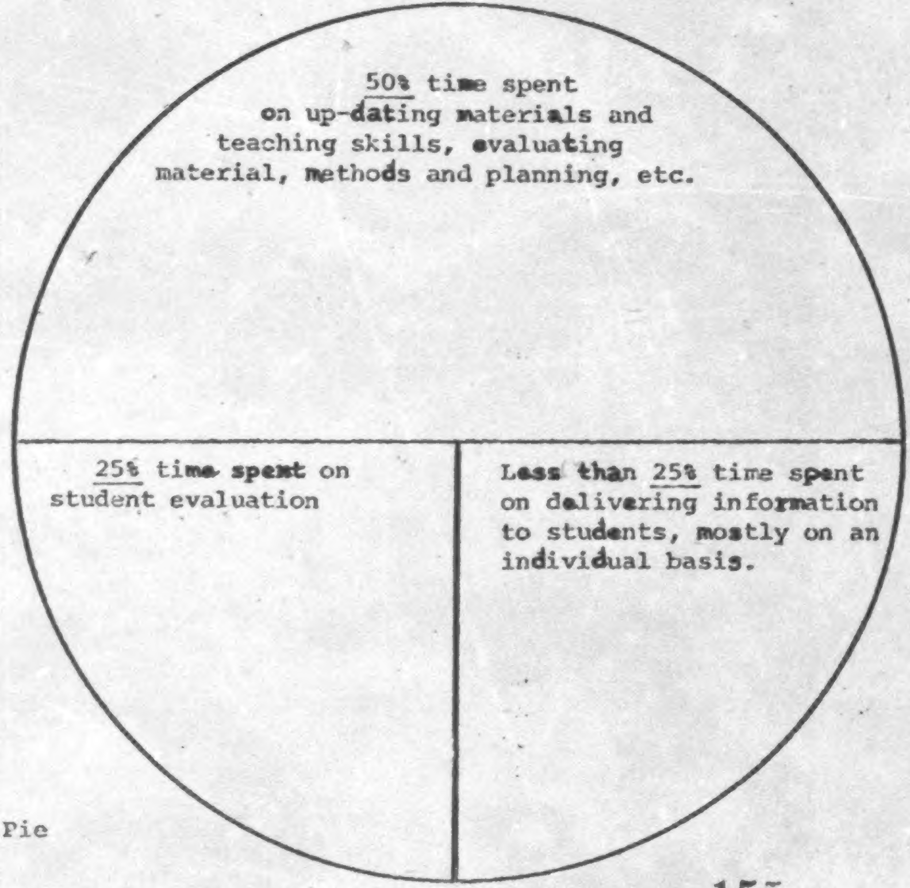
The instructor in TI does not usually have this time because he spends a large percent of his working day delivering information in person. In PI the amount of "delivery time" should be much less. The following graphs compare the estimated percent of time spent on various duties when utilizing TI and PI.

GRAPH Q



TI Pie

GRAPH R



PI Pie

PI and TI, as described here, would be similar to the PI and TI demonstrated in this study. One significant difference in the two graphs is the time spent delivering information. Again, it should be emphasized that these are estimated percentages.

Is this a true reflection of what has occurred at CPCC? The answer to this most critical question is yes and no. While in the developmental stage of PI, some instructor release time was made available. This release time was reduced substantially as the development continued and was gradually dropped completely. Today (1976) there is very little release time for development of new material or for any uses as previously described. What has happened is that paraprofessional personnel have been hired to replace the classroom instructor in the chemistry lab. Now instead of the instructor having this "release time" for the critically important duties such as student advising and diagnosis, development and revision of existing programmed materials, the instructor is assigned a heavier classroom teaching load. Working under these conditions the classroom instructor has less time available for revision of teaching material and individual student contact than under the previous system.

He is now spending just as much time delivering information as before (sometimes up to four or five different courses). Under the present system, the classroom instructor does not teach any lab classes and, therefore, has much less opportunity for student contact in the lab. The present system has, in effect, taken the classroom teacher away from the student!

Chemistry is presently and has always been an experimental science, meaning that the actual test of chemistry problems and their final solutions occurs in the lab. Practically all chemical laws have been proven in the lab. The chemistry lab is one major difference between the sciences and the non-sciences. This difference should be used to motivate students rather than turn them off. The lab is the place where students develop manipulative skills and techniques. It puts emphasis on the essential intellectual skills of science such as observation, organization and the interpretation of data.

If most of the important chemical facts, relationships, concepts, principles and laws have been discovered in the lab and are tested and rediscovered by chemistry students, obviously the chemistry lab should be the heart of a basic chemistry course. If this is true, then why should the teaching and/or supervision of labs be relegated to a paraprofessional?

One of the "sales pitches" used by community college administrators and faculty has been that "We are deeply concerned that students achieve and in the community college we don't relinquish the teaching of our basic courses to inexperienced graduate students, as the large university does." Today, for economics and other reasons, some community colleges have replaced the professional with the paraprofessional in very critical areas of teaching. Thus, we are guilty of the same error as the university in placing our potential in the hands of an educational novice.

Evidently, the students in this study may have recognized this problem as indicated in their choice of the closed chemistry lab.

In retrospect, during the innovative revolution that has taken place at CPCC, many mistakes have been made by both the faculty and administrators. However, in the opinion of the writer, there is much better teaching and learning taking place in chemistry at CPCC in 1976 than there was in 1971.

Recommendations

In consideration of the results and conclusions of the study, the following recommendations are made.

1. That the development and use of programmed material be continued and extended to include the entire general chemistry course.
2. That within the limits of economic feasibility, students should be given the option of programmed instruction or traditional instruction in chemistry at CPCC.
3. That the general chemistry lab be changed from a completely open lab to a semi-closed lab. In this system students and the classroom instructor would meet in a closed lab for approximately two-thirds of the time required to complete the entire experiments.

During this time, the student and teacher could solve any problemsand consider all questions. After this closed section, the lab could then be opened for a specified period of time for completion of the lab assignment and/or for repeating any needed work. During the closed lab, assigned teaching load on the basis of one lab hour being equal to one classroom hour would be maintained. During the open-lab period, the lab supervision could be handled successfully by a paraprofessional.

4. That further investigation be made to determine what relationships exist between such things as age, personality traits, professional ambition and achievement by TI and PI.
5. That further investigation be made to determine what effect PI has on the success of students in higher level chemistry courses and, later, in their professions.
6. That the administration make full use of the instructor "release time concept" presented in the discussion section of Chapter 6--not only give release time for the development of new course material but allow teaching credit for the continual revision and updating needed for PI i.e., Good lab experiments should be changed at least every two years! If this is not done, the programmed instruction may become antiquated in a short period of time.

7. That the administration and faculty should develop both merit pay and professional incentive programs to promote the continued development of good instructional materials.

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